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Adoption of Advanta sunflower hybrid seeds and its well-being impact on smallholder farmers in Dodoma, Singida and Manyara regions

*[1]MOMBO, W., [1]MALISA, E., [1]MASSAWE, G., [2]MULLUR, S., [1,3]KOMBA, M.

[1]Sokoine University of Agriculture, P.O. Box 3000 Morogoro, Tanzania
[2]Advanta Seeds International, Arusha, Tanzania
[3]Tanzania Agricultural Research Institute, P.O. Box 127 Bukoba, Tanzania

***Corresponding author**: mombowendy37@gmail.com

Abstract

Recently interventions have focused on rising agricultural productivity through the promotion of improved agricultural technologies such as seeds because these determine the income obtained from farming activities. This study assessed the adoption of and impacts of using Advanta sunflower hybrids seeds (ASHSs) on smallholder farmers' wellbeing. A multistage sampling technique was applied and a sample of 270 smallholder sunflower farmers was selected. The household survey questionnaires, focus group discussions and key informant interviews were used to collect primary data. Descriptive statistics run to profile the studied farmers with respect to their socio-economic characteristics. A binary logistic regression model helped to determine the factors that influence farmers' decisions towards the ASHSs Adoption. Propensity score matching was used to isolate the impact attributable to ASHSs among the smallholder farmers. Results indicated that yield per acre, number of years spent in school, seed price, household size, geographical location and oil content statistically influenced farmers' decision to adopt the ASHSs. There is a significant impact in terms of yield and income from the use of Hysun33 seed variety and the rest of the seeds (Aguara4). The average treatment effect on the treated (ATT) was positive for all the matching methods; ATT on yield was 201.32kg/acre and income effect of 95161.12 Tshs/acre for Nearest Neighbor Matching where ATT on yield was 155.97kg/acre and income effect of 122875.95 Tshs/acre for the Caliper Matching. Overall, a higher yield and income for the adopters was attributed to ASHSs compared to the non-adopters. This study recommended that agricultural development initiatives should promote productivity-enhancing agricultural technologies such as hybrid seeds effectively.

Key words: *Hybrid seeds; Impact; Income; Sunflower; Yield and adoption*

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Introduction

Rural development interventions have a major goal of improving beneficiaries' wellbeing and that is because wellbeing is one of the important indicators of development in many societies. Wellbeing is measured in many ways, but income still is a direct measurement because a household with enough income can easily meet its needs (Ahmed & Mesfin, 2017; Bilan *et al.*, 2020). Wellbeing however depends on the way people practice various activities as a means to obtain their day to day needs such as food, shelter, and clothing (De haan, 2017).

The wellbeing of people in Sub-Saharan Africa largely depends on agriculture therefore steps taken to improve agriculture are automatically set to improve farmers' wellbeing (Adebayo *et al.*, 2017). Regarding the benefits of agriculture, the perspective of many agriculture development interventions has focused on rising agricultural productivity. The interventions have been implemented through the promotion of improved agricultural technologies such as seeds because these determine the income obtained from farming activities.

In 2017, the Agricultural Marketing and Development Trust (AMDT) implemented a sunflower value chain project whose strategic objective was to increase the incomes of at least 150,000 smallholder farmers by 50% by the end of 2020. AMDT's interventions in the sunflower value chain were implemented in 11 regions which are Dodoma, Mbeya, Rukwa, Katavi, Songwe, Singida, Lindi, Mtwara, Manyara, Iringa and Njombe. To achieve this, AMDT intended to facilitate pro-poor systemic changes in selected market systems within the value chain, specifically the seed market, the core market where there is weak collaboration, and selected service markets (AGRA, 2021). For the seed market AMDT through Faida Mali and Farm Africa distributed Advanta sunflower hybrid, Hysun33 seeds to smallholder farmers in Dodoma, Singida and Manyara Regions, and offered training in good agronomic practices. Important traits of Advanta Sunflower Hybrid seeds, specifically Hysun33 seeds, include high yielding, high oil content, short maturity length, drought tolerance and disease resistance (Ogutu, 2018).
In Tanzania, sunflower is mentioned to be a priority crop in the central zone in the second phase Agricultural Sector Development Programme (ASDP II) in the criteria; viability of commercialization, scaling up and scaling out, and availability of technology to improve productivity and profitability (URT, 2017). Moreover, the government has mentioned sunflower to be a strategic crop and aims to advance the cultivation of this crop by empowering seed breeders and agricultural institutes to engage in massive research, invention and production of improved and certified seeds, hence this study has been conducted at the right time.

The basic question guiding this study is whether Advanta Sunflower Hybrid seeds have an impact on the wellbeing of smallholder farmers. Assuming that farmers behave rationally, they will decide to adopt improved technologies such as hybrid seeds that have a positive impact on their lives. Studies have focused on socio-economic factors that influence the decision of farmers to adopt improved sunflower seeds (Mujama and Izumida, 2019; Tibamanya *et al.*, 2021;). However, there is a paucity of information regarding the impact of these seeds on smallholder farmers' wellbeing. While the Government of Tanzania is determined to promote sunflower production (URT, 2017), there are improved seeds, including Hysun33, whose impacts on smallholder farmers' wellbeing is not known empirically. This study has attempted to establish the wellbeing impact of Advanta Sunflower Hybrid seeds, namely Hysun33 and Aguara4.

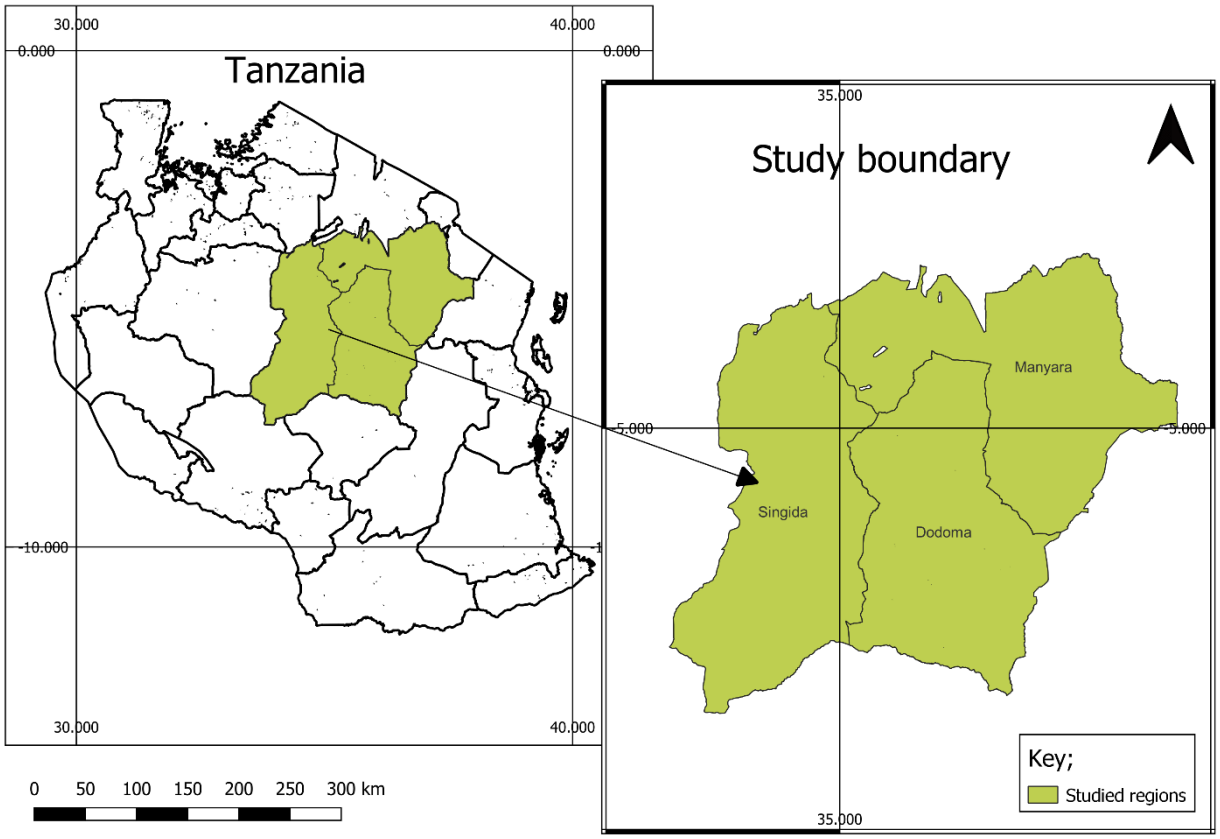
Materials and methods

Description of the Study Area

The study was conducted in Singida, Manyara and Dodoma Regions in Tanzania (Figure 1). These areas have been selected because Singida Region with 67 682 tonnes and yield of 0.5 tonnes/ha is the second highest in sunflower production followed by Manyara Region with 63 612 tonnes and Dodoma region was selected because it has the largest area (227 901 ha) of sunflower production with the highest yield of 202,528 tonnes in the country (URT, 2017). The mentioned study areas were purposely selected because AMDT through Faida Mali and Farm Africa implemented the sunflower value chain project with an objective to increase the incomes of smallholder farmers (AMDT, 2021). To achieve this objective, one of the key activities was to promote the use of Advanta Sunflower Hybrid seeds to improve productivity.

Figure 1

Map showing location of the study areas



Sampling Procedure and Sample Size

A multistage sampling procedure with three stages was used in this study. The first stage involved the purposive selection of districts and wards in Singida, Manyara and Dodoma Regions where Advanta Sunflower Hybrid seeds were introduced. One district was selected purposively from each region (Kongwa, Mkalama and Hanang) and 3 wards were also selected purposively from each district respectively. The second stage involved a random selection of two villages from each of the selected wards whereas the third stage involved a random selection of respondents (farmers) from the selected villages. These districts and wards were selected based on their use of Advanta Sunflower Hybrid seeds. From the same villages, a random selection of farmers who do not use hybrid seeds was done. In this regard, a list of farmers using Advanta Sunflower Hybrid seeds and another one entailing farmers not using hybrid seeds were obtained, followed by a random selection of farmers from the two lists.

Furthermore, people who are well informed on the subject matter of interest were selected for key informant interviews. These included agricultural extension officers, Advanta officials, project officers, and sunflower processors. Focus Group Discussions (FGDs) were used in this study whereby 3 FGDs were conducted each with 12 participants selected based on their use and experience on the improved seeds (Advanta Sunflower Hybrid seeds) and the rest of the seeds in sunflower production.

A sample size of 90 (15 farmers from each village) smallholder sunflower farmers was used for each region, which makes a total of 270 farmers from all three regions. The sample size of 270 farmers (90 from each region) is considered sufficient and can allow most statistical analyses to be conducted. According to Healey and Donoghue (2020), for data to be normally distributed the sample size has to be 30 and above.

The Data

Cross-sectional data were collected from sampled farmers using semi-structured household survey questionnaires; the data includes yield, costs of production, price of sunflower and farmer's socio-economic characteristics. Moreover, key informants' interviews were used to obtain more information from well knowledgeable people about the subject of interest and focus group discussions were also conducted to enrich the data from household surveys. Both qualitative data and quantitative data were used for this study because qualitative data in such a study is used to complement the quantitative data (Cresswell, 2014).

Data Analysis Techniques

Data entry and analysis was done with the use of statistical packages SPSS and STATA respectively.

Establishing smallholder sunflower farmers' socio-economic profile

Descriptive statistics that are frequencies, means, standard deviations, minimum, maximum and percentages were primarily used to profile the farm households in the study areas. Apart from farmers' profile descriptive statistics were also used to analyze farmers' awareness of Advanta Sunflower Hybrid seeds and the adoption level of these seeds.

Determination of the factors influencing the decision of farmers to adopt the sunflower hybrid seeds

A binary logistic regression model was used to determine the factors that influence the decision of farmers to adopt the sunflower hybrid seeds because the dependent variable-adoption decision is binary (decision on whether to adopt or not adopt hybrid seeds) (Healey and Donoghue, 2020). The logistic regression model is based on the probability function given as;

$$P_i = f(Z_i P_i = f(Z_i)$$

$$= \frac{1}{1+e^{-Z}} \frac{1}{1+e^{-Z}} \quad \text{.....(1)}$$

Where $P_i\, P_i$ is the probability of success, the probability that a farmer adopts the Advanta hybrid seeds, and $Z_i\, Z_i$ represents exposure to factors that may influence adoption, $Z_I = \alpha + \beta X_i\, Z_I = \alpha + \beta X_i$ and its probability is expressed below.

$$Z_i = \ln\left(\frac{P_1}{1-P_1}\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Thus.

$$Z_i = \ln\left(\frac{P_1}{1-P_1}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n + \varepsilon_i \dots\dots\dots\dots\dots (3)$$

Where $Z_i\ Z_i$ is Advanta hybrid seeds and $X_1, X_2, X_{3,} \dots X_n \quad X_1, X_2, X_{3,} \dots X_n$ are factors determining adoption, which include yield per acre, age, education, seed price, land size, household size, marital status, geographical location (region), oil content, membership in an association, non-farm sources of income and $\varepsilon_i \varepsilon_i$ is the error term

Propensity Score Matching (PSM)

The study used PSM to show the impact of adopting Advanta Sunflower Hybrid seeds by looking at the contribution of these seeds to smallholder farmers' wellbeing. In this study, a comparison on yield and income between adopters and non-adopters of Advanta hybrid seeds is made to establish the farmers' situation on the two variables if the seeds were not introduced in the study area.

Other studies such as Msuta and Urassa (2015), Adebayo et al. (2016) and Mushi (2019) used income as a direct measurement of wellbeing of smallholder farmers but income which is a proxy of profitability (gross margin) relates to yield therefore it is important to look past yield analysis because of the differences in production costs between adopters and non-adopters. Implementation of PSM involves four steps namely: propensity score estimation, checking overlap, selection of matching algorithm, estimating ATT.

Estimating propensity scores

Propensity scores are conditional probabilities of exposure to a program on a set of observable characteristics attributable to the program which are constructed using logit regression. The probability of each farmer to adopt the improved technology (Advanta's hybrid seeds) given their observable characteristics is computed to create a counterfactual group while assuming that farmers are adopting the technology or not adopting the technology but cannot do both. This is illustrated in the following equation.

$$p(X) = p(Z = 1|X) \dots\dots\dots\dots\dots\dots\dots\dots (4)$$

$$p(X) = p(Z = 1|X) \dots\dots\dots\dots\dots\dots\dots\dots (4)$$

Where $p(X)p(X)$ is the propensity score, ZZ is the binary dependent variable for adoption decision ($Z = 1Z = 1$ if farmer adopts and $Z = 0Z = 0$ if otherwise) and XX are observable socio-economic characteristics of farmers that may influence adoption decisions.

The binary logit model as a function of observable characteristics influencing adoption was used to estimate the propensity scores as specified in the following equations.

$$p(X) = Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n + \varepsilon_i \dots\dots\dots\dots\dots\dots\dots (5)$$

Checking overlap or balance

Once units are matched, the characteristics of the constructed treatment and comparison groups should not be significantly different. The balancing property explains that conditional distribution of observable characteristics ($X\, X$) given propensity score $p(X)p(X)$ is the same in both; the new technology adopters group and non-adopters group (Raitzer and White, 2017). The aim of checking overlapping or balance is to make sure groups are comparable and to avoid comparing the incomparable groups.

Selecting a matching algorithm

After estimating propensity scores, estimated units in the treatment group (adopters) were matched with counterfactual or control groups (non-adopters) with similar propensity scores.

Nearest Neighbor Matching (NNM) and Caliper matching algorithm. NNM involves matching adopters to the non-adopters' units with the closest propensity score. Caliper matching involves establishing a maximum propensity score radius (caliper) and all non-adopters within the given radius of an adopter are matched to that adopter (Awotide *et al.,* 2015).

Estimating the Average Treatment Effect on the Treated (ATT)

Yield effect

A production function was specified to determine the productivity effect from adopting the improved technology (Advanta's hybrid seeds) in terms of sunflower yield. The following equation indicates how the production function was specified.

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 D_1 + \cdots + \beta_n X_n + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where $Y_i\, Y_i$ is the productivity impact (yield in Kg/acre), X_i are determinants of yields Y_i these are such as farm size, household size, sex age and education. $D_1\ D_1$ is the dummy variable for the adoption of hybrid seeds ($D_1 D_1$= 1) if the farmer has adopted the improved technology and $D_1\ D_1$ =0 if the farmer has not adopted the improved technology and their yields denoted by Y_1 and Y_0 respectively

The adoption effect on yield was given by the following equations.

$$Y = ZY_1 Y = ZY_1 + (1-Z) Y_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7) Y_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$ATT = E(Y_1 ATT = E(Y_1 \mid Z=1) - E(Y_0 \mid Z=0) \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where $Y_1\ Y_1$ denotes the level of Productivity of a sunflower farmer who adopts technology ($Z = 1 Z = 1$); and $Y_0 Y_0$ is the level of productivity of sunflower farmers who do adopt Advanta Sunflower Hybrid seeds.

Income effect

Gross margin was used to represent profit or income attributable to the adoption of Advanta Sunflower Hybrid seeds. The gross margin equation is given in the following equation.

$$GM_t = \sum_{i=1}^{n} (TR - TVC) = \sum P_y\, Y - \sum P_x\ X_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where TR is the total revenue of selling sunflower, TVC is the total variable costs of producing sunflower and $P_y\ P_y$ and $P_x\ P_x$ are prices of sunflower and inputs respectively while YY and $X_i X_i$ are quantities of sunflower harvested and inputs respectively.

The average treatment effect on profit is given by the following equation.

$$ATT = \Big(E\big((P_1 Y_1 | Z = 1) - P_x X\big)\Big) - E\big((P_0 Y_0 | Z = 1) - P_x X\big) \ldots\ldots\ldots\ldots\ldots$$

Therefore

$ATT = E(GM_1) - E(GM_0) ATT = E(GM_1) - E(GM_0)$, where $GM_1\, GM_1$ and $GM_0\, GM_0$ are gross margins for adopters (using improved technology) and non-adopters respectively.

Results

Farmers' Socio-economic profiles

Results of this study indicate that 68.5% are male and 31.5% are female in which 6.3% of the farmers are single, 86.3 of the farmers are married. The marital status of the sunflower farmers may have an implication on the adoption of Advanta Sunflower Hybrid seeds since married couples can advise each other on whether to decide on adopting or not adopting Advanta hybrid seeds.

Only 8.5% of sunflower farmers were entirely not formally educated and 78.5% have acquired primary level education which is equivalent (Table 1) implying that 91.5% of sunflower farmers in the study area can at least read, write and count and may be more likely to choose to adopt than otherwise. Approximately two-thirds (66.7%) of the sampled sunflower farmers depend on farming as their main source of income while 2.6% of the total sampled sunflower farmers mentioned formal employment as their source of income. This implies that most sunflower farmers in the study area depend on farming as their main source of income therefore these people have the potential of producing more sunflowers with the

use of Advanta hybrid seeds, especially, if they are sensitized to the benefits of using these hybrid seeds.

Table 2

Factors influencing the adoption of Advanta Sunflower Hybrid seeds.

Variable	Odds Ratio	P>z
Yield/acre	1.003742	0.000***
Age	1.061078	0.126
Education	1.67817	0.005***
Land size	-0.9968857	0.978
Household size	-0.7662263	0.093*
Seed price	-1.000225	0.000***
Male	2.525715	0.369
Married	-0.4332162	0.461
Singida	11.31399	0.013**
Manyara	26.76947	0.007***
High oil content	932.1216	0.000***
Extension services	13.95603	0.021**
Development Agency	9.926887	0.100*
Farmer Association	0.4984988	0.500
Non-farm sources of income		
Yes	2.656969	0.244
_cons	1.35E-07	0.000

Note. Number of obs:270, Pseudo R^2: 0.2727, Chi-square: 101.75, Prob > chi2: 0.000. ***, **, *

Out of the 270 sample sunflower farmers 61.5% mentioned that they used their own land for sunflower cultivation and the rest used rented land for sunflower cultivation. Hence majority of the sunflower farmers do not incur the cost of renting land for sunflower cultivation, hence stand in a position to make more margins because the cost of renting land is deducted from the overall costs of production unlike those who use rented land.

Moreover, the average age of sunflower farmers is 46 whereas the minimum and maximum age are 20 and 78 respectively; therefore, most of the sunflower farmers in the study area are within the working group population therefore there is enough labour force availability in the study area. The average number of people within a household (household size) is 6 people. The mean size of land used for sunflower cultivation for the last production season was 2.75, implying sunflower farmers in the study area are small scale farmers (FAOSTAT, 2015). Farming experience in terms of the number of years a farmer has been cultivating sunflower where the mean number of farmers have been cultivating sunflower is 12.6 years. Thus, sunflowers are one of the main crops produced within the study areas.

Awareness of farmers and adoption level of Advanta Sunflower Hybrid seeds

Study findings in Figure 2 show that most sunflower farmers are aware of Advanta Sunflower Hybrid seeds. More than three-quarters of the total sample (81.5%), when asked if they are aware of the Advanta Sunflower Hybrid seeds or not, responded that they are aware whereas 18.5% of the total sample responded that they are not aware of the seeds

Out of the farmers who were aware of the seeds, 67.3% had adopted the seeds whereas 32.7% of

those who were aware had not adopted the seeds. Among the Advanta hybrid seeds adopters, 97.3% had adopted Hysun33 and only 2.7 % had adopted Aguara4 which are hybrid varieties from Advanta Seed Company. Figure 2 Indicates the level of adoption of Advanta seeds with respect to regions in which farmers reside. Lack of awareness about Advanta seeds explains why those who were not aware had not adopted the seeds. In addition to that, the price of these may be a major reason why those who are aware have not adopted the seeds because a focus group discussion conducted in Manyara explained that:

> "*Most farmers prefer local seeds because they are sold at a low price and some people do not even buy because they reuse the seeds from previous years but for the modern seeds like Hysun33 which is sold at 35 000Tshs per Kg, that is very expensive for us and it increases the cost of production*." [FGD Participant, Manyara. 04/03/2021]

These results are in line with the expected utility theory, where the farmers have compared the costs of the seeds and have opted not to adopt because they find it not to benefit them as the cost of production increases.

Moreover, the cross-tabulation indicated that there is a positive relationship between awareness of Advanta Sunflower Hybrid seeds and geographical locations. In this regard, Singida Region farmers were more aware of the seeds compared to the other regions.

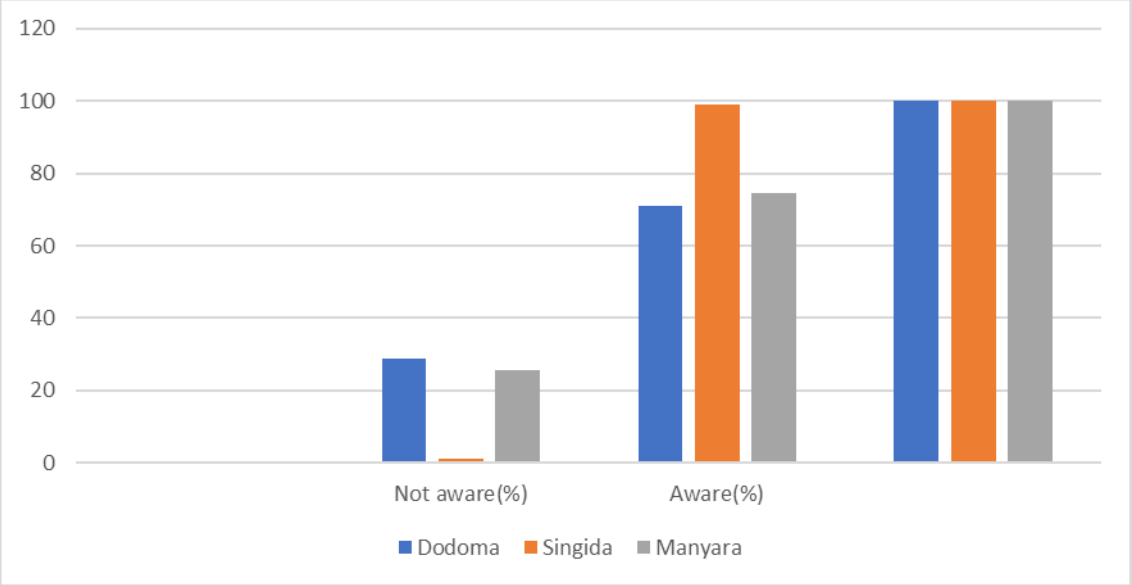
This may be since there were different project coordinators in each region therefore even the strategies of spreading awareness are different leading to different awareness outcomes. Furthermore, based on their observation, most farmers in Dodoma seem to not be motivated to learn about improved seeds, this information links to the explanation by one of the key informants who stated that:

> "*……farmers in Dodoma are quite different from farmers in other regions, most of them are not interested and for the ones that are interested wish to get seeds for free.*

Figure 2 illustrates further the level of awareness among farmers with respect to the regions in which they are found. Farmers' awareness plays an important role in the decision to adopt improved sunflower seed varieties. It is expected that when farmers understand and appreciate the innovation of the improved sunflower seed varieties, they would accept it. Kimathi et al. (2021) have argued that smallholder farmers will adopt the improved seed when they view the innovation as beneficial to them.

Figure 2

Awareness status of Advanta sunflower seeds across Dodoma, Singida and Manyara



Factors influencing adoption of Advanta Sunflower Hybrid seeds

Table 2 shows the regression results that indicate eight variables; Yield per acre, education level (number of years spent in school), seed price, household size, region, oil content, extension service and development agency are significant determinants of the adoption of Advanta Sunflower Hybrid seeds in the study areas.

Yield per acre has a significant influence on farmers' decision to adopt at $p < 0.01$ and a positive implication that farmers with high productivity have a higher probability to adopt Advanta Sunflower Hybrid seeds. Further, the variable education is significant at $p < 0.01$ has a positive implication on the probability of the farmers to adopt Advanta hybrid seeds, that is the higher the education level or the more the years a farmer spent in school the higher the probability of the farmer to adopt Advanta Sunflower Hybrid seeds. This is because it is easy to educate farmers who are educated on the importance of using improved seeds so that they can adopt them.

The average household size of the farmers in the study areas is 7, therefore according to the regression results, farmers with higher household sizes are less likely to adopt the seeds and household size is significant at $p < 0.1$. This can be explained in the sense that large households usually have more dependents compared to small households hence posing a constraint in the probability of adoption decision.

Seed price is also significant at $p < 0.01$ but has negative implications in influencing the decision of a farmer to adopt Advanta Sunflower Hybrid seeds. Meaning that a unit increase in hybrid seed price would have caused a decrease in the likelihood of adopting sunflower hybrid seeds.
The region in which the farmer is located is also a

significant influence on the adoption of these seeds. In this regard, Singida is significant at $p < 0.05$ and Manyara is significant at $p < 0.01$ that is farmers residing in Singida and Manyara are more likely to adopt Advanta hybrid sunflower hybrid seeds than farmers located in Dodoma. These regions are significant at different P-levels because there are different project coordinators in each specific region hence different strategies of influencing farmers to adopt the seeds.

Oil content also has a positive implication on the decision of the farmer to adopt or not to adopt these seeds meaning that farmers are likely to adopt these seeds because of the high oil content, oil content is a significant factor at $p < 0.01$. Oil content may attract farmers to adopt these seeds because they can benefit from processing the sunflower into oil rather than selling it as it is. These results conform to the results from a study by Justin (2012), which showed that oil content had a positive and significant association with the adoption of sunflower innovation.

Extension service has a significant relationship with the adoption of Advanta sunflower seeds at $p<0.05$ and a positive implication. Extension services may influence adoption since extension officers spread information about improved technologies and encourage farmers to use these technologies.

The variable development agency also has a significant and positive relationship with the adoption of Advanta sunflower seeds at a 90% confidence interval. This is because development agencies play a great role in agricultural interventions and introduce improved agricultural technologies with the purpose of improving productivity.

Table 1

Farmers' Socio-economic characteristics

Sex of the respondents	**Frequency**	**Percent**
Female	85	31.5
Male	185	68.5
Total	270	100.0
Marital status		
Single	17	6.3
Married	233	86.3
Widow/widower	12	4.4
Separated	8	3.0
Total	270	100.0
Education (years spent in school)		
School years		
No formal education	23	8.5
Primary education	212	78.5
Secondary education	28	10.4
Tertiary education	7	2.6
Total	270	100.0
Source of income		
Farming (crop cultivation)	180	66.7
Livestock keeping	57	21.1
Craftsman	1	.4
Formal employment	7	2.6
Business	25	9.3
Total	270	100.0
Type of and ownership		
Own Land	166	61.5
Amount of land rented	104	38.5
Total	270	100.0

Contribution of Advanta Sunflower Hybrid seeds to farmers' wellbeing

The covariates used to compare farmers in this study are presented in Table 3 and the summary of probabilities indicates that the average probability is 0.533. According to White and Raitzer (2017), covariate balancing property score must be estimated by weighting to propensity score estimates to ensure covariates are balanced before propensity scores are applied in matching. This helps to avoid comparing incomparable groups. Therefore, a balance check was done first by visual inspection, using histogram, on the distribution of propensity scores between adopters and non-adopters of Advanta Sunflower Hybrid seeds whereas the histogram showed a similar distribution of propensity scores between the adopters (the treated group) and non-adopters (counterfactual).

Table 3

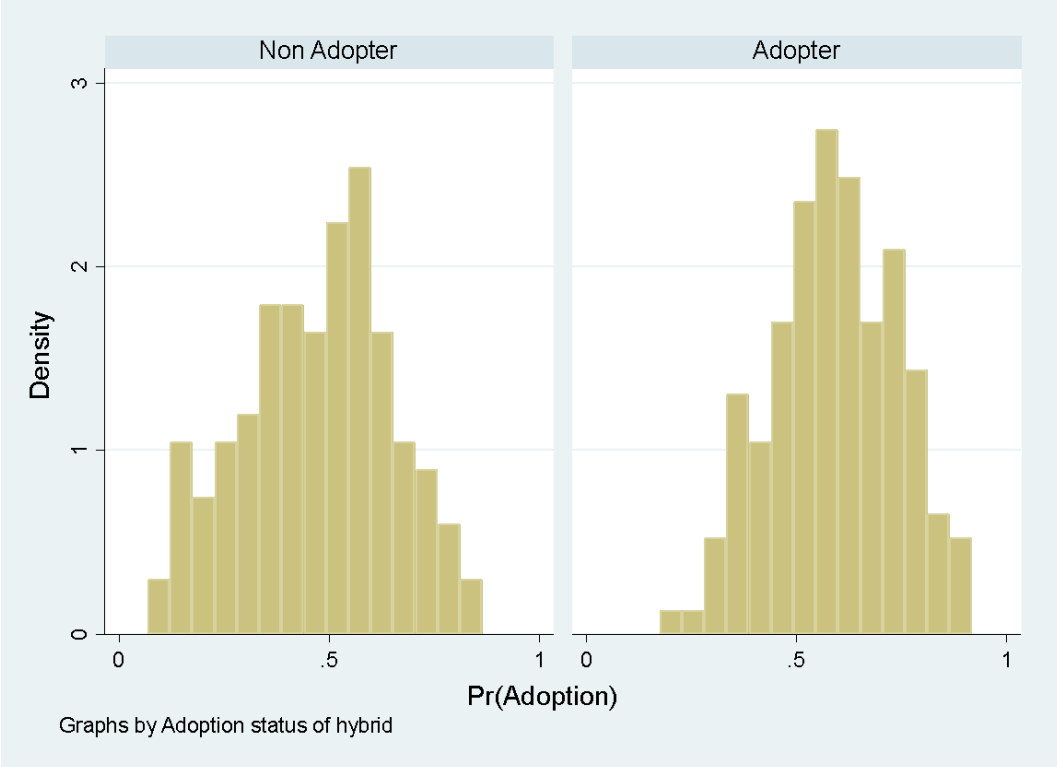
Farmers' probabilities of adopting Advanta Sunflower Hybrid seeds are used in estimating propensity scores.

Adoption	**Coefficient**	**Z**	**P > z**
Sex	.6613135	2.15	0.031
Age	-.0227464	-1.73	0.083
Marital status	.1947386	0.65	0.515
Education	.1392195	2.66	0.008
Household size	-.0010308	-0.02	0.981
Income sources	.0315929	0.27	0.789
Land size	.0937508	1.53	0.125
Ownership of land	-.2700876	-0.96	0.336
Processing/ selling	.139868	0.67	0.501
Farmer's group membership	.8158169	2.82	0.005
Farming experience	.0254092	0.096	1.67
_cons	-1.493803	-1.40	0.161

The histogram presented below shows (Figure 3) that the densities of probabilities lie within the same region of common support (a range where the propensity score lies).

Figure 3

Distribution of propensity scores among adopters and non-adopters of sunflower hybrid seeds



To make sure that there is a propensity score balance between the treated and untreated group, a test for each variable in the logit model specified was conducted to estimate the probabilities to see if their means are comparable. The results from the test indicated that the propensity scores range between (region of common support) 0.068 and 0.917. For the adopters, the region of common support lied between 0.187 and 0.917. For the non-adopters, propensity scores ranged between 0.068 and 0.837. After the balancing property is satisfied it is then possible to compute the mean output differences between adopters and non-adopters of Advanta Sunflower Hybrid seeds.

Yield impact of using Advanta Sunflower Hybrid seeds

The results from Nearest Neighbor Matching (NNM) algorithm show that farmers who adopted Advanta hybrid seeds had higher crop productivity than sunflower farmers who did not adopt. The NNM results indicate that the average yield per acre for the treated group (adopters) was 531.25 Kg/acre compared to 329.92 Kg/acre for non-adopters which presents a difference of 210.32 Kg/acre (Table 4). Similarity is seen in the unmatched group of farmers where there is a difference of 217.80 Kg/acre between the adopters and non-adopters. The t-statistics is 6.48 and 4.12 for matched and unmatched respectively, which means that the difference in yield estimated between adopters and non-adopters is

statistically significant at a 99% confidence interval because t-statistics is greater than 2.58 (Healey and Donoghue, 2020). In this case, the results suggest that smallholder sunflower farmers who use Advanta Sunflower Hybrid seeds have higher sunflower productivity compared to non-adopters because these seeds are improved seeds and hence, they are high yielding.

Similarly, the Caliper Matching results also show that the adopters of Advanta Sunflower Hybrid seeds experience a higher yield by 155.97 Kg/acre (Table 4). The t-statistics is 2.67 implying that there is a statistical significance at a 99% confidence interval in the difference between adopters and non-adopters (ATT).

Income impact of Advanta Sunflower Hybrid seeds

The gross margin, which is a proxy for profit, was used to indicate the impact of Advanta sunflower hybrid seeds on the income of sunflower farmers. The NNM results indicate that the ATT in terms of income is 95 161.12 Tshs/acre for the matched individual and 122 875.95 Tshs/acre (Table 5) for the unmatched individuals. Furthermore, the ATT on farmers' gross margin income effect of adopting Advanta Sunflower Hybrid seeds is positive and significant for both matched and unmatched individuals. The Caliper results also show that there is an impact on the income of smallholder farmers since the ATT is 108171.76 TZS per acre and the t-statistics are significant (t-statistics = 3.00) at a 99% confidence interval since it is above 2.58.

This means with the increase in income preceding the use of Advanta seeds, farmers can increase more assets, expand income-generating activities, diversify dietary consumptions, send their children to school and meet many other needs.

Discussion

This study has added up to other studies such as ones conducted by Tibamanya *et al*. (2021) and Liu *et al*. (2018) that already exist on the knowledge about the determinants of adoption of agricultural technologies such as hybrid seeds. Results in this study indicated that eight variables which were yield per acre, education level (number of years spent in school), seed price, household size, region, oil content, extension service and development agency significantly determined the adoption of Advanta Sunflower Hybrid seeds in the study areas. Particularly, higher yield per acre of hybrid seeds meant its high productivity and eventually higher probability to adopt Advanta Sunflower Hybrid seeds. These results conform to the results from a study by Mushi (2019) which focused beyond socio-economic characteristics of farmers as factors influencing adoption, in his yield had a significant influence and a positive implication on the decision of farmers to adopt bean hybrid seeds. Another variable found decisive in adopting hybrid seeds was education. More years spent by a particular farmer in education increased the probability for them to adopt the hybrid seeds. A study by Lunduka *et al*. (2019) has similar results that indicate education to have a significant influence on the adoption of improved maize seeds variety.

Furthermore, household size was found negatively related to the chance of seed adoption. These results are contrary to the results by Tibamanya (2021) where household size had a positive implication on the binary adoption decision, it was further explained that more members of the household potentially get information about the improved seed varieties. Also, as expected seed price and hybrid seed adoption decision were negatively related. A study by Mwalongo *et al*. (2020), had similar results, this means farmers are not adopting the seeds because of their own price of seeds which leads to an increase in the cost of production.

Nonetheless, the region that the farmer was residing in influenced the adoption chance. In fact, farmers residing in Singida and Manyara were more likely to adopt Advanta hybrid sunflower

hybrid seeds than farmers located in Dodoma.This aligns with the results by (Tibamanya, 2021) who also indicated how the area in which the farmer is located relates to the adoption of improved seeds.

Also, oil content attracted farmers to adopt these seeds such that hybrid seeds with higher oil content were in the bigger chance to accept the seeds over those with lower oil content because they can benefit from processing the sunflower into oil rather than selling it as it is. These results conform to the results from a study by Justin (2012), which showed that oil content had a positive and significant association with the adoption of sunflower innovation.

Equally important, as conjectured increase in extension visit to sunflower farmer was revealed to increase the likelihood of the farmer to adopt hybrid seeds holding other things unchanged. From the accessed literature, results look identical to the results of a study conducted by Chandio and Yuansheng (2018), where extension services had a positive and significant implication to improved seeds.

Moreover, surveyed farmers involved with development agencies were found to have a higher chance to accept hybrid seeds compared to their counterparts simply because development agencies offer additional support to the farmers either technically or financially, hence increasing their accessibility and affordability to improved seeds. This aligns with a study by Gairhe *et al*. (2017), which also indicated that a development agency had an implication towards the adoption of improved seeds.

The impact of adopting hybrid seeds on farmers' wellbeing was also caught statistically. The results in Table 5 suggest that smallholder sunflower farmers who used Advanta Sunflower Hybrid seeds have higher sunflower productivity compared to non-adopters because these seeds are improved seeds and hence, they are high yielding. These findings conform to the results of studies conducted by Adebayo *et al*. (2016), Lunduka *et al*. (2017) and Mushi (2019) of the impact of improved seeds on the yield of smallholder farmers which indicated that farmers who used improved seeds had more yield compared to those who did not use improved seeds.

Most important from the analysis is that the adoption of hybrid sunflower seeds also improved the income generated by the practicing farmer. These results are similar to results from studies conducted by Mpogole and Kadigi (2012), Smale and Mason (2014), Adebayo *et al*. (2016), Lunduka *et al*. (2017) and TerAvest *et al*. (2019), which used income as a direct measurement of wellbeing and indicated that farmers that used improved seeds had more income compared to farmers who did not use the hybrid seed.
Furthermore, the results concerning the impact in this study relate to the theory of change which is a statement of how the inputs being provided (funds, people, and changes in regulatory or policy environment) lead to intended outcomes and impacts. In this case, the inputs are the improved seeds that lead to improved wellbeing in terms of yield and income.

Conclusion and Recommendations

The decision on whether to adopt or not to adopt is significantly influenced by variables, yield per acre, education, household size, seed price, geographical location, oil content, extension services and development agency. Coefficients of household size and seed price are negative while the coefficients of the rest variables are positive, this means as household size decreases then the probability of a farmer to adopt increases and vice versa is true this could be because higher household size indicates higher dependency ratio. The price of the seeds also has the negative implication of the decision to adopt which means farmers are less likely to adopt Advanta due to the price. On the other hand, all other variables had positive coefficients meaning that the probability of farmers adopting these seeds

increases with these variables.

Furthermore, results indicate that adopting Advanta Sunflower Hybrid seeds improves smallholder farmers' productivity and income. There is a significant impact of these seeds on the yield per acre and income per acre obtained by smallholder farmers hence they contribute to the improved productivity of sunflowers in the study areas. During the group discussion with farmers, however, the major complaint was about the higher price of the improved seeds compared to the local ones. These complaints confirmed that farmers still use local seeds because they are cheap.

Based on the interpretation and discussion of the findings of this study, the following are the recommendations: Firstly, the study recommends that there should a promotion of the use and/or adoption of Advanta sunflower hybrid because they improve the wellbeing of smallholder farmers since the result of this study shows that the adoption Advanta Sunflower Hybrid seeds have improved the smallholder farmers' yield and income.

In addition to that, in further increasing the seeds accessibility, the study recommends that the distribution channels of the Advanta Sunflower Hybrid seeds be revisited, in particular the linkage between the seed producers, contractors (for the case of contract farming), agro-dealers and farmers who are the final consumer of the seeds. The study found an information gap along the distribution channels as some farmers reported to have no information about the seeds and where they can buy seeds. Since most farmers both adopters and non-adopters obtained information about the Advanta Sunflower Hybrid seeds through the organizations which implemented the project through their farmer association groups, then it is suggested that if farmers are encouraged to join these groups and seeds producers deliver seeds to farmers association groups farmers will easily access the seeds.

Moreover, the study recommends that processors should work closely with farmers through contract farming and provide farmers with improved seeds (credit) with the expectation to source sunflower seeds harvested from these farmers for processing into oil. This will encourage farmers to use these seeds because they are sure of the accessibility of the seeds despite the price of the seeds.

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References

Adebayo, O., Olagunju, K., & Ogundipe, A. (2016). Impact of agricultural innovation on improved livelihood & productivity outcomes among smallholder farmers in rural Nigeria. Available at SSRN 284753.

Ahmed, M. H., & Mesfin, H. M. (2017). The impact of agricultural cooperatives membership on the wellbeing of smallholder farmers: Empirical evidence from eastern Ethiopia. *Agricultural & Food Economics, 5*(6), 1-20.

Bilan, Y., Mishchuk, H., Samoliuk, N., & Yurchyk, H. (2020). Impact of income distribution on the social & economic well-being of the state. *Sustainability, 12*(1), 429.

Chandio, A. A., & Yuansheng, J. (2018). Determinants of adoption of

improved rice varieties in Northern Sindh, Pakistan. *Rice Science, 25*(2), 103-110.

Creswell, J. W. (2014). *Qualitative, quantitative, and mixed methods approaches*. Sage.

De Haan, L. (2017). Rural and urban livelihoods, social exclusion and social protection in sub-Saharan Africa. *Geografisk Tidsskrift-Danish Journal of Geography, 117*(2), 130-141.

FAOSTAT. (2015). Production of sunflower seeds in Tanzania. Retrieved from http://www.faostat.org

Gairhe, S., Gauchan, D., & Timsina, K. (2017). Adoption of improved potato varieties in Nepal. *Journal of Nepal Agricultural Research Council, 3*, 38-44.

Healey, J. F., & Donoghue, C. (2020). *Statistics: A tool for social research and data analysis*. Cengage Learning.

Justin, L. (2012). Factors contributing to adoption of sunflower farming innovations in Mlali Ward, Mvomero District, Morogoro Region – Tanzania (Master's thesis, Sokoine University of Agriculture). Morogoro, Tanzania.

Kimathi, S. M., Ayuya, O. I., & Mutai, B. (2021). Adoption of climate-resilient potato varieties under partial population exposure and its determinants: Case of smallholder farmers in Meru County, Kenya. *Cogent Food and Agriculture, 7*(1).

Liu, T., Bruins, R. J., & Heberling, M. T. (2018). Factors influencing farmers' adoption of best management practices: A review and synthesis. *Sustainability, 10*(2), 1-26.

Lunduka, R. W., Mateva, K. I., Magorokosho, C., & Manjeru, P. (2019). Impact of adoption of drought-tolerant maize varieties on total maize production in South-Eastern Zimbabwe. *Climate and Development, 11*(1), 35-46.

Mpogole, H., & Kadigi, R. M. (2012). Round potato (Solanum tuberosum) profitability and implications for variety selections in the Southern Highlands of Tanzania.

Msuta, B. P., & Urassa, J. K. (2015). The contribution of farmers' organizations to smallholder farmers' well-being: A case study of Kasulu district, Tanzania.

Mujama, R. M., & Izumida, Y. (2019). Factors affecting farmers' decision on crops selection with special reference to new technology: Case of sunflower seed and sweet potato in Ikungi District, Tanzania. *International Journal of Environmental and Rural Development, 10*(2), 80-85.

Mushi, E. (2019). Farm livelihood impact of apron star 42 ws–dressed bean seeds and its commercialization viability in Mbeya and Mbozi districts, Tanzania (Doctoral dissertation, Sokoine University of Agriculture).

Mwalongo, S., Akpo, E., Lukurugu, G. A., Muricho, G., Vernooy, R., Minja, A., Ojiewo, C., Njuguna, E., Otieno, O., & Varshney, R. (2020). Factors influencing preferences and adoption of improved groundnut varieties among farmers in Tanzania. *Agronomy, 10*, 1-15.

TerAvest, D., Wandschneider, P. R., Thierfelder, C., & Reganold, J. P. (2019). Diversifying conservation agriculture and conventional tillage cropping systems to improve the wellbeing of smallholder farmers in Malawi. *Agricultural Systems, 171*, 23-35.

Tibamanya, F. Y., Milanzi, M. A., & Henningsen, A. (2021). Drivers of & barriers to adoption of improved sunflower varieties amongst smallholder farmers in Singida, Tanzania: The double-hurdle approach (No. 2021/03). *IFRO Working Paper*.