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Differentials in Adoption of Maize Seed Varieties and Impact on Farmers' Livelihood in Northern Nigeria

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Abstract
Small-scale farmers in Nigeria are at a huge risk due to climate change which has negative impact on agricultural productivity. One way of improving productivity in Nigeria is by exposing small-scale farmers to improved seed technologies and innovations. This study assessed the adoption of maize seed varieties and its impact on farmers' livelihood in five states of northern Nigeria. The study is based on comprehensive data set collected through field survey and questionnaire administration from 195 maize farmers segregated into 80 adult male (AM), 66 adult female (AF) and 49 youth (Y). The ordered Probit regression model and propensity score matching analysis were employed for empirical analysis; nearest neighbour matching was chosen among the three algorithms that included the stratification and kernel matching, due to its robustness across the three group of farmers. The data analysed showed that drought resistance was most preferred attribute considered for adoption of improved maize variety by AM, high yield and marketability by AF and requirement of other inputs by Y, while socio-economic and institutional variables were the major drivers of their adoption. The impact of improved maize seed variety revealed that the treatment effect on the treated had a positive and significant impact on maize yield across the three groups of farmers. It is therefore recommended that relevant research institutes and government should collaborate with extension service of ADP to mobilize farmers at grassroots for capacity building to enhance preference to adoption.

Keywords: Adoption, maize, productivity, and ordered Probit model

Introduction

Maize (*Zea mays L.*) is one of the most important cereal crops in the world after wheat and rice, and perhaps one of the most important food and industrial crop widely consumed as a staple food by every household in Nigeria. According to PWC (2021), about 45.5% of locally produced maize in Nigeria is processed as animal feeds, 13% for manufacturing industrial flours and confectionaries, 10-15% for household consumption and 6.5% is used by brewing companies. Nigeria is the second largest maize producer in Africa, and largest producer in sub-Sahara Africa (Tegbaru *et al.*, 2020), contributing 12.77% to Africa, about 43% to sub-Saharan Africa (SSA) and 0.98% to world maize production in 2021 (USDA, 2022). It is cultivated in many parts of Nigeria, but predominantly in the northern part and used for human food, animal feed and as raw materials for industries including brewing beer (Usman *et al.*, 2022). Hence, an important source of carbohydrate, protein, iron, vitamin B, and minerals (Shah *et al.*, 2016; Ignjatovic-Micic *et al.*, 2015: Kumar and Jhariya, 2013; Sandhu *et al.,* 2007). In Africa, particularly Nigeria, and most countries in SSA, small scale farmers are at huge risks due to climate change which have negative impact on agricultural production (Okpara *et al.*, 2022).

However, agriculture holds great potential as solutions to major sustainable development goals and global challenges of this century including eradicating poverty, achieving food security and self-sufficiency, as well as mitigating and adapting to climate change, as critical resources like water, energy and land become increasingly scarce. It is the largest sector of the Nigerian economy and a main source of livelihood to most rural Nigerians which employs about 36% of the country's labour force and contributed about 24.65% of the nominal Gross Domestic Product (GDP) and a real GDP of 26.95% in the fourth quarter of year 2020, with crop production contributing the largest share of about 89% nominal GDP (National Bureau of Statistics, NBS, 2021; Usman *et al.*, 2022). One way of transforming agriculture and improving productivity in Nigeria is by exposing small-scale farmers to improved agricultural production technologies and innovations (Isah, 2022). According to Sunding and Zilberman (2001), technological change has been a significant factor driving modernization and improvement in agriculture in the recent past. For instance, a comparison of agricultural production pattern in the United States of America in 2000 and 2011 indicates that gross farm income increased to USD425.0 billion in 2011 from the figure of USD225.0 billion in 2000, while cultivated land declined from 945,080 in 2000 to 916,990 million acres in 2011. (USDA, 2012). This implies an increase in agricultural productivity. The foremost explanation for such increase is changes in agricultural production method, topmost among which is the use of innovative technologies such as improved seed varieties.

Seed is the key input in all crop production. All cultural practices are designed to exploit the full genetic potential of the seed sown and no agricultural practices like tillage, weeding, fertilizer and pest and disease control can increase crop yields beyond the limit set by the seed quality (Ali and Rahut, 2018). The growing activism of drought tolerance maize variety (DTMVs) stems from the concern that it is an efficient seed production technology that enhance agricultural productivity under climate change such as variability in vagaries of rainfall patterns or changing rainfall precipitation, threat of pests and diseases infestation, genetic weakness, and of course inputs requirements and market supply-demand specific traits among others (Usman *et al.*, 2022; Tegbaru *et al.*, 2020; Vabi *et al.*, 2019). The adoption of this innovation by maize farmers in Nigeria has numerous benefits; mainly to improve productivity and high income, poverty reduction and enhance household food security among small-scale farmers (Chete, 2021; Kadafur *et al.*, 2020; Tegbaru *et al.*, 2020; Adedipe *et al.*, 2017).

The productivity of maize production of the farmers at the national level in Nigeria level is still exceptionally low compared to what is obtainable in other countries due to limited availability of improved seeds and low adoption of best agronomic practices in crop production. In SSA, the mean maize yield was 1.7 metric tons per hectare which is less than one-third of the global average (FAOSTAT, 2021). It is pertinent to note that Nigeria farmers for many decades relied solely on the local varieties with low yield, low resistance to disease and pests and with long maturity periods; a situation that led to low productivity and production (Usman *et al.*, 2022; Tegbaru *et al.*, 2020; Vabi *et al.*, 2019). Improved quality seed is not only the economical and basic input of increasing yields but also fundamental in raising the efficiency of other inputs like fertilizers and agro chemicals; yet, access to resources is essential to improving agricultural productivity and efficiency across all category of gender (Awotona and Oladimeji, 2020).

It suffices to note that perspectives, needs, priorities and constraints towards enhancing the productive potentials vary among men, women and youth (Agada *et al.*, 2018). In Nigeria like many countries of SSA, low agricultural productivity is driven by the challenges in gender disparity in access, control, and utilization of production resources (Muricho *et al.*, 2020; Rufai *et al.*, 2015). According to FAO (2011), and Kanu *et al.* (2017), women contribute about 50% of agricultural labor; yet, structural barriers limit female farmers' productivity in the African agricultural landscape. Despite many years and efforts on recommended agricultural technology in Nigeria including improved seed and seedling, agricultural production methods and yield have remained low. In an attempt to improve livelihood among rural farmers and also to increase the productivity and incomes of the rural inhabitants to meet up with the Sustainable Development Goals (SDGs) of food sufficiency and poverty eradication, maize adoption and impact analysis is imperative to identify the roles, differences and discriminations between men, women and youth's productivity and outcomes, which poses a serious threat to the efficiency of agricultural development programs. This paper assessed men, women and youth disaggregated data on adoption of drought tolerant maize varieties (DTMVs) and its impact on farmers' livelihood in northern Nigeria.

Methodology

Nigeria is an Afro-tropical country in West Africa with a landmass of approximately 923,768.6 km^2 and projected population of about 200 million people in 2020 (NBS, 2019). The study was carried out in savannah zone Northern Nigeria (Figure 1). Maize performs optimally under a temperature of 21 and 27^0C, rainfall of between 480-880 mm per annum and a well-drained sandy soil (Kamara *et al.*, 2020). Primary data was collected in the year 2021, with the aid of structured questionnaire administered to DTMVs farmers in the study area by trained enumerators through personal interview method. The DTM, Stress Tolerant Maize (STMA) and Accelerating Genetic Gains (AGG) in maize are an IITA assisted project funded by the International Maize and Wheat Improvement Center (CIMMYT) and executed by the Institute of Agricultural Research (IAR), Ahmadu Bello University, Zaria. IITA in collaboration with IAR, Samaru-Zaria funded by the Bill and Melinda Gate Foundation supported the release of about 30 DTMVs (SAMMAZ 15-44 varieties) and 24 STMAs (SAMMAZ 45-68 varieties) including three newly released varieties with Accelerated Genetic Gain (AGG) maize parental traits. A multi-stage sampling procedure was employed to select DTMVs farmers for the study.

The first stage involved selection of the five (5) project States: Bauchi, Jigawa, Kaduna, Kano and Katsina States (Table 1). The second stage involved a random selection of one LGA each, from the selected states using the balloting system. These LGAs include; Toro (Bauchi), Brinin-Kudu (Jigawa), Giwa (Kaduna), Gwarzo (Kano) and Danja (Katsina). The third stage involved the selection of all the eight (8) adopted villages from the selected LGAs that participated in the DTMVs and STMA on-farm trials in chosen States. The adopted villages, well thought out, was a strategic attempt by the IAR to encourage large-scale adoption of improved technologies, empower resource-poor farmers economically, create job and wealth opportunities, and ensure food security in Nigeria. The fourth and final stage involved random selection of 195 maize farmers who adopted improved maize seed varieties, from a sample frame of 380 maize farmers. This comprises of 80 adult male, 66 adult female and 49 youths (Table 1). On the other hand, 178 maize farmers who are non-adopters of improved seed varieties with similar socio-economic characteristics were randomly selected from a sample frame of 320 as counterfactual in impact analysis. It is pertinent to note that six varieties predominantly planted in the survey period were documented.

Conceptual framework and analytical techniques

The data collected were analyzed using both descriptive and inferential statistics. Ordered Probit model was employed to determine the drivers of adoption which include socio-economic and institutional characteristics of the maize farmers. Adoption rate was measured as proportion of farmland in hectares planted with DTMVs maize to total farmland cultivated with maize production.

The ordered Probit model is specified implicitly as follows:

$$\text{Prob}\ (\text{Choice}_{ij} = j) = \frac{nx}{\sum_{j=1}^{j} e^{\propto jxi}} \ldots..1$$

Where: i represents ith farmer, and i=1,2,3,…,195. ; j represents different adoption rates

The explicit form of the Ordered Probit is specified as:

$$Y_{i\text{-}j} = \beta_0 + \beta_1 X_1 i + \beta_2 X_2 i + \_\_\_\_\_ + \beta_9 X_9 + e \ldots\ldots (2)$$

Where: Y's is the adoption rate denote by size of farmland planted with DTMVs by 1, 2, ……,195 DTMVs farmers who adopted the improved; Prob represents the probability of adoption rate j to be chosen by the maize farmers; $\text{Choice}_{ij} = j$ means that :

Y_1 = 100 – 66.31 % of farmland (ha) planted with DTMVs (High);

Y_2 = 66.30 – 33.3 % of farmland (ha) planted with DTMVs (Moderate); and

Y_3 = < 33.30 % of farmland (ha) planted with DTMVs (Low);

j is chosen by the respondents; β_0 = constant term and β_1- β_9 = regression coefficients; X_1= farming experience (years), X_2 = size of total farm land (ha), X_3= household size (number of persons), X_4= level of education (number of years), X_5 = amount of credit accessed for maize production (₦), X_6 = distance of input centres to farm village (km), X_7= cooperative membership (years), X_8 = number of visits from and to agricultural advisors/scientists/seed companies including demonstration and training in 2021 (number), X_9 = grants and aids received from government and NGOs (₦) and e is the error term. The marginal effects were estimated as the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean.

Theoretical basis of Propensity Score Matching (PSM) model

Impact assessment requires a group affected by the programme or an intervention (such as adoption of DTMVs), and a control group not adopting improved seed varieties to compare the outcomes such as yield and income. Then, the difference between the two groups is defined as the impact of the adoption programme. To examine this causal effect of adopting DTMVs by smallholder farmers, the matching approach was employed. Using PSM techniques, the average maize yield of individuals that used improved seed to that of control groups can be compared.

Let Y*i* be the outcome that would result if an individual adopts improved seed v and Y*o* the outcome that would result if the same individual did not adopt improved seed varieties. For improved livelihood impact analysis, Let D = (0, 1) denote the binary indicator of adopting hybrid seed (*D* = 1 if adopted, 0 otherwise). For a given individual i, the observed farmer's yield is then

$$Yi = YOi + Di\,(Y1i - Yoi) \ldots. (3)$$

Following Heckman *et al.* (1997), the average treatment effect on the non-treated (ATU) is:

ATU = E(Yi - Yo/D = 0) ... 4

ATU is the average yield difference between the potential yield that the farmers who did not adopt improved seed (D = 0) would get if they had (E(Yi)) and the real yield that they produce (Yo). The Average Treatment Effect on the Treated (ATT) which is the parameter of interest is given as;

$$\delta \equiv E\{Y_i^{\,1} - Y_i^{\,o}/D_i{=}1\} = E\ \{E\ \{Y_i^{\,1}/D_i = 1, P\,(Z_i)\} - E\ \{Y_i^{\,o}/D_i{=}0, P\,(Z_1)\}D_i = 1 \ldots\ldots (5)$$

Where; $P\,(Z_i)$ is the *P-Score, Yi* is the potential outcome (maize yeild) in the counterfactual situation of adopting treatment (DTMVs) and no treatment (non- adopters).

Two important properties of the P-score matching are the balancing property and conditional independence assumption (CIA). Testing for this property is important to ascertain if maize farmers' behavior within each group is actually similar. CIA states that adopting DTMVs is random and uncorrelated with the maize yield by the farmer, once the set of observable characteristics, *Z* are controlled for.

Results and Discussion

Table 2 shows the mean and standard deviation of socioeconomic and institutional variables of adult male, adult female and youth used in ordered Probit and propensity score models for adoption of DTMVs and its impact on farmers' livelihood. The result reveals that there were significant difference in the age of household heads, farm experience and household size among farmers categories as the chi-square were statistically significant at 1% level of probability. The proportion of credit utilized for maize production and remittances by farmer categories were also statistically significant. Therefore, the results exhibit wide variation and disparity in terms of socio-economic and institutional characteristics among the gender based maize farmers. Awotona and Oladimeji (2020) and Croppenstedt *et al.* (2013) noted that improving productivity will depend to a great extent on ensuring that all the categories of gender have sufficient access to production inputs and support services.

Rate of adoption of improved maize varieties

Results in Figure 2 depict that youths has the highest rate of adoption level (66.3-100%) of about 55.1% compared to adult male (51.3%) and adult female (33.3%). The youths may be more accessible to input centres and urban market because of access to mobility such as *okada* and phones. On the other hand, adult female has the least adoption level which could be attributed to the current practice of Purdah (women in seclusion) as the people of the study area are predominantly Muslims.

Adoption of drought tolerance maize varieties (DTMVs)

Table 3 shows the result of the adoption of selected major DTMVs popular among sampled farmers. The rate of adoption result depict that, about 49% of the adult male farmer preferred SAMMAZ 55. A good number of the adult female (30%) preferred SAMMAZ 32, while about 29% of the youths preferred SAMMAZ 55. From the mean percentages, the three most preferred varieties in the study area were SAMMAZs 55, 32 and 51. The chi-square test was used to check for significant difference in adoption of improved varieties among the categories and this was statistically significant at 5% level of probability. In addition, majority of adult male (86.3%), adult female (81.8%) and youth (55.1%) cultivated local maize variety along with improved ones. This implies that a significant difference exists in the adoption for DTMVs among farmers' group. The reasons for different uptake of recommended seed-based technologies based on category and from one area to another are enormous and these includes but are not limited to project actions essentially demonstrations, availability of improved seeds, persistent awareness capacity strengthening, relative affordability of farm technologies, less income and asset holdings of the farmers, negative attitudes, insufficient know-how, and severe agro-ecological conditions (Vabi *et al.*, 2019; Suhane *et al.*, 2008). It is suggested that research institutes and government agencies should collaborate with extension service of ADP to mobilise farmers at grassroots for capacity building which will increase their preference to adoption.

Attributes considered in adoption of maize varieties

The study also examined some of the DTMVs traits preferred by farmers in the improved maize varieties. Farmers prefer different crop varieties for different reasons. Figure 3 shows the result of the attributes considered in adoption of each improved maize seed cultivated. Results showed that almost all the attributes listed were important to farmers as both male and female identified drought resistance as one of the most important traits in maize variety cultivation while adult female sought for high yield (87.9%), and youth ranked less requirement of other inputs (85.7%) as most preferred traits. Hence, maize breeders should consider the need for adjustment in breeding to improve partnerships with farmers based on group requirements. This can be done through on-farm trials and take cognizance of other value chain actors such as food scientists, postharvest specialists and private seed sector on the packaging and delivery of seed technologies to farmers and these other value chain actors as also canvassed by Tegbaru *et al.* (2020).

Determinants of drivers of adoption of improved maize varieties

The result of analysis of the ordered Probit regression model for the factors influencing the adoption of DTMVs by category in selected states in northern Nigeria is presented in Table 4. The results revealed a good fit for the data as log likelihood function were for adult male (-178.6), adult female (-196.4) and youth (-84.3) with Prob > chi^2 which were statistically significant at 1% level of probability. Therefore, the model specified explained significant non-zero variations in factors determining adoption of improved maize varieties. The marginal effects or the coefficients of variables that were statistically significant were interpreted using *xb* options where the margin related to the linear predictors (Williams, 2021; Torres-Reyna, 2011). The marginal effect of farming experience for adult male (0.421) was statistically significant at 5% level of probability while the marginal effects of both adult female (0.221) and youth (0.006) were positive but not statistically significant. The positive and significant marginal effect of farming experience for adult male indicate that the probability of adopting improved maize varieties will increase as the farming experience increase. This could also stem from longer years of farming experience of adult male compared to either adult female or youth, which ensured transfer of skills, knowledge and sharing of experience which is necessary for growth and development of maize production. Chete (2021), Baruwa *et al.* (2015), and, Ojo and Ogunyemi (2014), also found significant positive relation between farming experience and probability of adoption of improved maize varieties in their respective studies in Nigeria.

The marginal effect of total farmland cultivated was statistically significant for adult female (0.003) and youth (0.631) at 10 and 1 %, respectively. The positive signs of the marginal effects of farm size cultivated imply that an increase in the size of farmland will lead to likelihood of increased cultivation of the improved maize variety. Adedipe *et al.* (2017) found positive relationship between increase in farm size and adoption of improved maize variety among farmers in West Africa. The result of analysis of marginal effect of dependency ratio shows that the marginal effect of adult male (-0.321) was statistically significant at 1% level of probability. The result implies that the higher level of dependency ratio may reduce the probability of level of adoption of improve seed variety. This is because the households with more unproductive members per household would probably have much to cater for and little to purchase improve maize variety. In other words, if the number of children or dependents is high, it will weigh much burden on the household head. This also connotes that farmers with larger households have a higher probability of embracing innovation only if the larger proportion of household are active or working class. The result is comparable with studies of Chete (2021); Kadafur *et al.* (2020) and, Adedipe *et al.* (2017) on factors affecting maize seed adoption technology in Nigeria.

The result of the marginal effect of education for youth was positive (0.119) and statistically significant relationship with adoption at 5% level of probability. This implies that a unit increase in level of education will increase adoption of improved seed varieties by 11.9%. This suggests that youth farmers that are educated are likely to adopt improved varieties more compared to illiterate farmers. Chete (2021); Kadafur *et al.* (2020) and Adedipe *et al.* (2017) also found that the level of education is believed to influence the use of improved technology in maize production in their studies of maize adoption in Nigeria. The marginal effects credit utilized for maize production of adult female (0.447) and youth (0.420) were positive and statistically significant at 1 and 10 %, respectively. In the same vein, the marginal effect of being a member of cooperative society and social organization was also positive and statistically significant for the adult female (0.003) and youth (0.004) at 10 and 1 % level of probability. Cooperative society involve a social participation that helps maize farmers to pool their resources together, to have access to inputs including seed variety, credit finance, to diffuse new innovations and techniques and to have interaction with other as well as share information on modern maize production practices.

The result of the analysis of the distance of farm household to markets revealed that the marginal effects of all the three categories of farmers viz. adult male (-0.018); adult female (-0.621) and youth (-0.221) were negative and statistically significant at different levels of probability. This implies that a unit increase in farm distance to markets for either adult male, adult female or youth category will lead to likelihood of increase in transport cost. This may invariably affect the final market prices of the produce in the study area. It is pertinent to note that access to markets is an incentive to buy improved inputs and improved infrastructure such as road networks and transportation if available reduce transportation costs and farm gate prices improves. The marginal effect of extension contact for adult male was found to be positive (0.204), while that of youth was negative (-0177) and both significantly related to factor influencing decision to adopt improved maize varieties. This result implies that respondents with high number of extension contacts have greater chance of adopting the farming technologies. Odoemelam *et al.* (2020) observed that farmers tend to utilize the agricultural technologies disseminated to them especially by the extension agents, and the finding from regression result showed that the coefficient of extension service delivery had impact on the use of improved cassava technologies among the cassava farmers in the study area. Similarly, the marginal effect of grants received from government and NGOs, and remittance from family and relatives was also statistically significant for adult male (0.527) and youth (0.107) which is also pointer to increase adoption of maize seed variety. Chete (2021) and Kadafur *et al.* (2020) also found extension services as significant determinants of adoption of improved maize variety.

Impact of DTMVs on livelihood of maize farmers' in Northern Nigeria

The results of the impact of improved maize seed on maize farmers' livelihood presented in Table 5 revealed that the Treatment Effect on the Treated (ATT) on the average had a positive impact and statistically significant at 1% across the farmers' category. The results of the Nearest Neighbor Matching (NNM) were reported due to its robustness across the three categories of farmers. The ATT increases maize yield of adult male, adult male and youth farmers by 1047.9, 1505.2 and 1487.5 kg/ha, respectively. Thus, it could also be concluded that utilizing improved maize varieties impacted positively on the yield of group-based farmers by their respective coefficients. The Average Effect of the Treatment (ATE) for group-based farmers that adopt improved maize varieties increase by 1,874.0, 1,903.9 and 1.801.1 kg/ha for adult male, adult female and youth, respectively compared to the treated farmers. The Treatment Effect on the Untreated (ATU) was estimated by matching similar treated group-based farmers to each non-treated household. The result shows that ATU had a significant and positive coefficient across the three group-based farmers group by 2,004.1, 1,865.0 and 1,995.3 kg/ha, impact on yield, this is the counter factual outcome of the treated had it been they were not treated.

Constraints faced in accessing improved seed variety

Figure 4 described constraints faced in accessing improved seed variety based on adult male, adult female and youth. Results showed that high seed price per kilogram, non-availability and market adulteration were the most critical constraints for both male and female maize farmers. Other constraints include; transport cost of procuring the maize seed, difficulties in variety identification and accessibility.

Conclusion

The present study is among the few studies focused on maize hybrid adoption in Nigeria. The empirical results indicate that socio-economic and institutional variables are largely the drivers of adoption of the improved maize seed in Northern Nigeria across the respondent. The adoption of DTMVs has shown to impact positively and significantly on the yield of grouped-based farmers. The wider adoption can only be ensured through scaling up and down of the project to enhance increased variety adoption by farmers. Breeders must also pay attention to the need for adjustment in breeding to improve partnerships with farmers based on group requirements through on-farm trials. They also have to take cognizance of other value chain actors on the packaging and delivery of seed technologies to farmers and other value chain actors.

References

Adedipe, O., Olarinde, L. O., and Fatunbi, A. O. (2017). Determinants of Adoption of Improved Maize Varieties in Kano-Katsina-Maradi, West Africa. *African Crop Science Journal,* 25(1): 1 – 11.

Agada, M. O., Onuche, F. I., and Mbah, E. N. (2018). Gender Participation and Constraints in Cassava Production, Processing and Marketing in Makurdi, Benue State, Nigeria. *International Journal of Gender and Women's Studies,* 6(1): 79-87.

Ali, A. and Rahut, D. B. (2018). Hybrid Maize Seed Adoption and Impact on Livelihood: Empirical Evidence from Maize Growers in Pakistan. Proceeding of 36th International Conference, July 28th – August 2nd, 2018. Pp. 1-8.

Awotona, T. O. and Oladimeji, Y. U. (2020). Technical Efficiency in Cassava Production among Farmers in Oyo state, Nigeria: A Gender Situation Analyses. *Nigeria Agricultural Journal,* 51(3): 28-35.

Awotona, T. O., Oladimeji, Y. U. and Damisa, M. A (2022). Analysis of Gender Dynamics in Cassava Production for Resource Empowerment Among Farmers in Oyo State, Nigeria. *Agrosearch Journal,* 21(1&2): 32-45.

Baruwa, O., Kassali, R. and Aremu, F. (2015). Adoption of Improved Maize Varieties among Farming Households in Osun State, Nigeria. *Prod. and Agric. Tech*., 11(2): 1-9.

Chete, O. B. (2021). Factors Influencing Adoption of Improved Maize Seed Varieties among Smallholder Farmers in Kaduna State, Nigeria. *Journal of Agricultural Extension and Rural Development,* 13(2): 107-114.

Croppenstedt, A., Goldstein, M. and Rosas, N. (2013). Gender and Agriculture: Inefficiencies, Segregation, and Low Productivity Traps. Policy Research Working Paper, No.6370, the World Bank. 31pp.

FAO (2011). The State of Food and Agriculture: Women in Agriculture, Closing the Gender Gap for Development; FAO: Rome, Italy, 2011. 160pp.

FAOSTAT, (2021). FAO Report. www.faostat.org

Heckman, J., Ichimura, H. and Todd, P. (1997). Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Program. *Review of Economic Studies*, 64: 605-654.

Ignjatovic-Micic, D., Vancetovic,J., Trbovic, D., Dumanovic,Z., Kostadinovic,M. and Bozinovic, S. (2015). Grain Nutrient Composition of Maize (*Zea mays L.*) Drought-Tolerant Populations. *Agric. Food Chem.*, 63: 1251−1260.

Isah, U. S. (2022). Adoption of Agricultural Technology: How Far Have Farmers Gone? Federal University of Minna, Inaugural Lecture Series 99. Pp. 13-21.

Kadafur, I. M., Idrisa, Y. L., and Shehu, A. (2020). Adoption of Improved Maize Varieties in Northern Guinea Savannah of Borno State, Nigeria. *Journal of Agricultural Extension,* 24(1): 34-42.

Kamara, A.Y., Kamai, L. O., Omoigui, A., Togola, A. and Onyibe, J. E. (2020). Guide to Maize Production in Northern Nigeria: Ibadan, Nigeria. IITA, Pp.18.

Kanu, R.U., Mazza, M. and Obioma, Q. N. (2017). Women Farmers as Veritable Tools in Rural Community Development: A Case Study of Michael Okpara University of Agriculture Umudike model communities in Abia State, Nigeria. *Nigerian Agricultural Journal,* 48(2):99-104.

Kumar, D. and Jhariya, N. A. (2013). Nutritional, Medicinal and Economical Importance of Corn: A Mini Review. *Research Journal of Pharmaceutical Sciences*, 2: 7–8.

Muricho, G., Lokossou, J., Ognon, H. A., Ahmed, B., Desmae, H., *et al*. (2020). Estimating and Decomposing Groundnut Gender Yield Gap: Evidence from Rural Farming Households in Northern Nigeria. *Sustainability,* 12(8923): 1-20.

NBS (2019). National Bureau of Statistics. www.nigerianstat.gov.ng

NBS (2021). National Bureau of Statistics (2021). https://www.nigerianstat.gov.ng/download/1229

Odoemelam, L. E., Onu S. E. and Obungwu, E. (2020). Extension Service Delivery and Use of Improved Cassava Technologies Among Farmers in Enugu state Nigeria. *Nigerian Agricultural Journal,* 51(1): 96-100.

Ojo, S. O. and Ogunyemi, A. I. (2014). Analysis of Factors Influencing the Adoption of Improved Cassava Production Technology in Ekiti State, Nigeria. *International Journal of Agricultural Sciences and Natural Resources*, 1(3): 40-44.

Okpara, B. O., Offor, E. I. and Iwezor, M. D. (2022). Determinants of Productivity in the Presence of Risk Encountered by Arable Crop Farmers in Umuahia South LGA, Abia State, Nigeria. *Nigerian Agricultural Journal,* 53(1): 124-131.

Rufai, A., Salman, K. and Salawu, M. (2018). Input Utilization and Agricultural Labour Productivity: A Gender Analysis. In Building a Resilient and Sustainable Agriculture in SSA, Shimeles *et al.,* A., Eds.; Palgrave Macmillan: Cham, Switzerlsand.

Pp. 55-79.

Sandhu, K. S., Singh, N. and Malhi, N. S. (2007). Some Properties of Corn Grains and their Flours I: Physicochemical, Functional and Chapati-Making Properties of Flours. *Food Chemistry*, 101: 938–946.

Shah, T. R., Prasad, K. and Kumar, P. (2016). Maize—A Potential Source of Human Nutrition and Health: A Review. *Cogent Food and Agriculture,* 2: 1-9.

Suhane, R. K., Sinha, R. K. and Singh, P. K. (2008). Vermicompost, Cattle-Dung Compost and Chemical Fertilizers: Impacts on Yield of Wheat Crops. Communication of Rajendra Agriculture University, Pusa, Bihar, India. Pp. 56-86.

Sunding, D. and Zilberman, D. (2001). *The Agricultural Innovation Process: Research and Technology Adoption in a Changing Agricultural Sector*. A Handbook of Agricultural Economics. 1(1): 207-261.

Tegbaru, A., Menkir, A., Baco, M. N., Idrisou, L., Sissoko, D., Ayinde O. E., Abate T. and Abdoulaye, T. (2020). Addressing Gendered Varietal and Trait Preferences in West African maize. *World Development Perspectives,* 20(100268): 1-20.

Torres-Reyna, O. (2011). Predicted Probabilities and Marginal Effects after (Ordered) Logit/Probit Models Using Margins in STATA. http://www.princeon.edu/torres/

USDA (2012). United States Department of Agriculture. National Agricultural Statistics Service Report. Retrieved 27th August 2022 from http://www.usda.download

USDA (2022). United States Department of Agriculture, (2022). National Agricultural Statistics Service Report. Retrieved 27th August 2022 from http://www.usda.download

Usman, H. A., Oladimeji, Y. U., Egwuma, H. and Abdoulaye, T. (2022). Gender Gaps inProfitability of Drought Tolerant Maize Varieties (DMTVs) Production in Selected States of Northern Nigeria. in 10th Int. Conf. on Soc. Sci. and Humanities, *in Dari et al.* 2022, Silvas University of Sci. and Tech., Turkey, July 18th – 19th 2022. Pp. 264-273.

Vabi, M. B., Sadiq, A. S., Mustapha, A., Suleiman, A. A., ognon, H., Ajeigbe, H. A. and Kasim, A. A. (2019). Patterns and Drivers of the Adoption of Improved Technologies in North-Western Nigeria. *Africa Journal of Agriculture,* 6: 1–16.

Williams, R. (2021). Adjusted Predictions and Marginal Effects for Multiple Outcomes Models and Commands. 2021 Revision, http://www.nd.edu/williams

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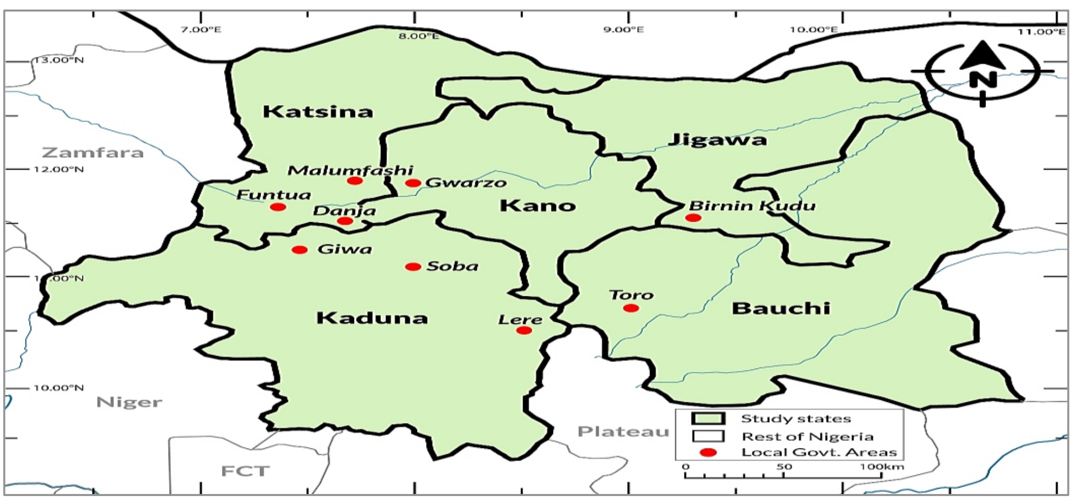

Figure 1: Map of Nigeria showing the study States and Local Government Areas (LGAs)

Table 1: Sampling procedure and sample size of DTMVs and non-DTMVs farmers

State	LGA	Villages	Sample frame (Adopters)	Sample size (Adopters: 51%)	Sample frame (non-adopters)	Sample size (non-adopters: 56%)
Bauchi	Toro	Laru	52	27	45	25
		Nabaka	41	21	34	19
Jigawa	B-kudu	Brinin-kudu	50	26	30	17
Kaduna	Giwa	Napri village	55	28	43	24
Kano	Gwarzo	Bakula	36	18	38	21
		Kasira	48	25	31	17
		Angalawa	40	20	56	31
Katsina	Danja	Tatari	58	30	43	24
5	5	8	380	195	320	178

Source: Reconnaissance Survey, (IAR/IITA/DTMA Project, 2021)

Table 2: Farm-household characteristics of respondents

Variables	Adult male Mean ± sdev	Adult female Mean ± sdev	youth Mean ± dev	Chi[2] X^2
Age of household head (years)	54.9±6.2	47.9±8.3	29.7±5.8	11.02
Farm experience (years)	35.6±12.8	27.0±7.2	15.0±4.5	17.21
Household size (number)	8.9±3.2	6.9±1.7	4.1±1.2	12.29
Dependency ratio	0.7±0.2	0.6±0.2	0.2±0.04	1.96
Proportion of married status ratio	0.8±0.2	0.9±0.1	0.5±0.5	na
Level of formal education (years)	5.3±2.3	4.9±2.2	9.7±4.8	1.46
Amount of credit accessed ('000N)	38.9±17.3	16.4±9.1	95.9±27.0	16.93
Cooperative membership (years)	7.5±1.7	5.8±3.0	4.3±2.9	11.75
Extension contact (number)	3.9±2.1	0.9±0.2	2.1±0.6	1.04
Remittance/aids ('000N)	16.6±12.5	27.9±6.4	3.0±1.4	22.43
Total farm size (ha)	2.8±0.9	1.2±0.4	1.5±0.7	22.54
Maize farm size (ha)	2.3±0.2	0.8±0.2	1.3±0.4	17.05
DTMVs farm size (ha)	1.0±0.3	0.6±0.2	0.9±0.3	1.09

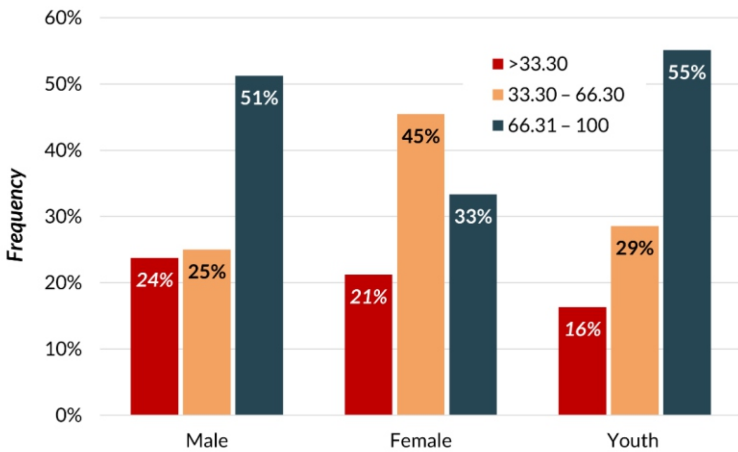

Figure 2: Descriptive statistics of level of adoption by maize farmers

Table 3: Distribution of farmers' adoption DTMVs in northern Nigeria

	Adult male		Adult female			Youth	Mean
Variety	F	%	F	%	F	%	% mean
DTMVs							
SAMAZ17	5	6.25	4	6.06	4	8.16	15.03
SAMAZ18	-	-	2	3.03	1	2.04	3.71
SAMAZ32	21	26.25	20	30.30	9	18.37	62.68
SAMAZ50	-	-	6	9.09	11	22.45	16.57
SAMAZ51	15	18.75	19	28.79	10	20.41	54.34
SAMAZ55	39	48.75	15	22.73	14	28.57	81.0
Total	80	100.0	66	100.00	49	100.00	
X^2 - Value	31.17						
P-value	0.000						
Local	69	86.25	54	81.82	27	55.10	

X^2 =chi square

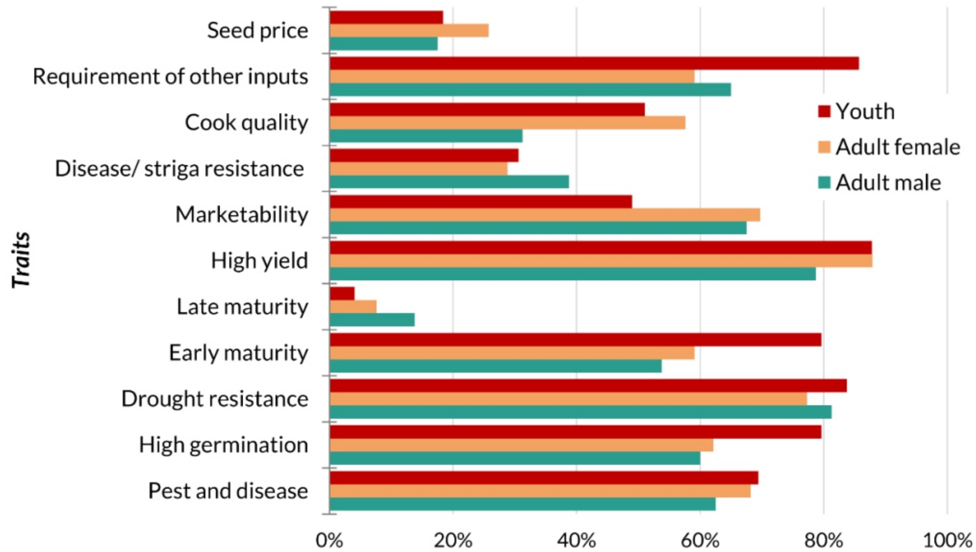

Figure 3 : Distribution of attributes considered in adoption of DTMVs (Multiple response allowed)

Table 4: Determinants of the drivers of adoption of DTMVs

Variables	**Adult male**		**Adult female**		**Youth**	
	dx/dy	**t-ratio**	**dx/dy**	**t-ratio**	**dx/dy**	**t-ratio**
Constant	0.054	2.15**	0.004	2.49***,	0.117	2.03**
Farming experience	0.421	2.09**	0.221	1.29	0.006	1.41
Total Farmland cultivated	-0.007	-1.09	0.003	1.98*	0.631	3.97***,
Dependency ratio	-0.321	-2.65***,	0.001	0.86	0.003	0.72
Level of education	0.004	1.08	-0.218	-0.74	0.119	2.02**
Credit accessed for DTMVs	0.172	0.95	0.447	3.06***,	0.421	1.83*
Cooperative membership	-0.001	-1.05	0.003	1.98*	0.004	3.05***,
Distance to input centres	-0.018	-2.03**	-0.621	-4.96***,	-0.221	-2.87***,
Number of visits/trainings	0.204	1.97*	0.000	0.74	-0.177	-2.40**
Grants/aids/remittances	0.527	2.09**	0.217	0.84	0.107	1.96*
Diagnostic statistics						
No of observation	80		66		49	
LR Chi^2 (8)	27.3		31.08		17.42	
Prob > Chi^2	0.003		0.001		0.07	
Pseudo R^2	0.16		0.14		0.09	
Log likelihood	-178.6		-196.4		84.3	

Note: ***, **, * denote significance at 1, 5, 10 % level of probability

Table 5: Impact of DTMVs adoption on farmers' yield

Group	Estimation by	Sample	β	SE	T-value	P> /Z/
	Yield (Kg)	ATT	1047.9	305.51	3.43	0.000
Adult male		ATE	1874	594.92	3.15	0.004
		ATU	2004.1	527.39	3.8	0.001
Adult female	Yield (Kg)	ATT	1505.2	386.94	3.89	0.003
		ATE	1903.9	539.35	3.53	0.005
		ATU	1865	382.96	4.87	0.008
Youth	Yield (Kg)	ATT	1487.5	436.22	3.41	0.000
		ATE	1801.1	581	3.1	0.000
		ATU	1995.3	681.0	2.93	0.001

*Note: *** P<0.01 level of probability,*

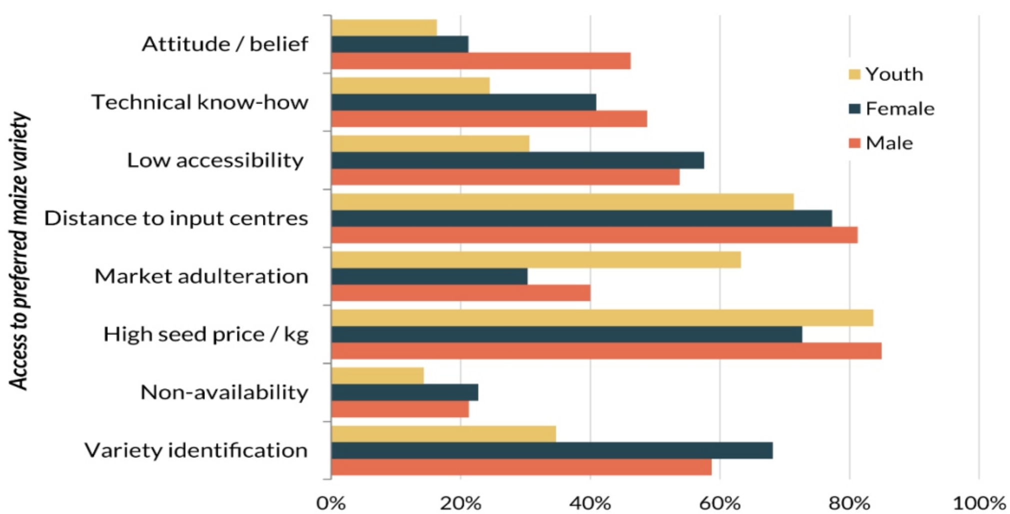

Figure 4: Constraints encountered in accessing DTMVs (Multiple responses)