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Research Article
Impact of Technology Adoption on Household Income: The Case of Tef in Dendi District, Ethiopia

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Abstract

Background and Objective: Tef is the most important cereal crop and the main staple food for more than 70 M people. The average productivity of the crop is very low compared to other cereal crops and the spatial variability of the productivity of the crop is very high across different districts and peasant associations within the region and different regions of the country. Therefore, this research was intended to assess the impacts of the adoption of improved and high-yielding tef varieties on the improvement of household income in the Dendi District. **Materials and Methods:** This study used 210 sample households from five peasant associations in the Dendi District. Descriptive and econometric data analyses were done. The propensity score matching method and logistic regression model were used for econometric data analysis. **Results:** The result revealed that household heads who are using improved and high yielding tef technologies on average get more income of 7943 birrs compared to household heads that are non-users of tef technologies. **Conclusion:** Based on the result of this research, improving the awareness of tef farmers towards adoption of high yielding improved tef technologies will contribute more to improving the household income and their livelihood specifically and also contribute to improving national income generally.

Key words: Adoption of tef, Dendi District, household income, impact, logistic regression, PSM

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Tef is the most important indigenous cereal crop in Ethiopia, which is the leading crop in terms of the area of production, is about 3 million hectares and the second in total production next to Maize CSA cited in Nigus *et al.*[1]. Tef serves as the main staple food for more than 70 million people and its straw is highly utilized as livestock feed[2,3]. It is also getting popularity across the globe as it is a gluten-free and healthy food. Tef is grown for food and animal feed in different countries like Australia, the United States, Israel, the Netherlands, Eritrea, India, Pakistan, South Africa, Uganda, Mozambique and Kenya[4,5].

Tef is a nutritious crop containing essential nutrients like protein, carbohydrates, ber, fat and minerals[6]. It is also rich in some minerals like iron which is significantly higher than the amount that we can get from bread wheat[7]. But, the average productivity of tef is lower compared to other cereals as different factors are contributing to this low productivity. Tef production in Ethiopia is facing immense production constraints that affect the yield potential of the crop, including lodging, low inputs, inappropriate sowing method, post-harvest losses and using low yielding local varieties[8,9].

The agricultural sector of Ethiopia in general is mainly characterized by small-scale and subsistence, which is inevitably affected by different factors like extreme weather, poor agronomic practices, lower rates of inputs and low qualities of inputs. To overcome these problems and improve production and productivity, the Ethiopian government is recently implementing cluster farming as a new farming approach in which the leading and the coordination role was given to agricultural research centres, regional state, governmental and non-governmental organizations. Technical and material support like provision of pieces of training, seed, fertilizer and types of machinery, certification of product quality and facilitation of market linkage. This approach is expected to accelerate technology dissemination, enhance information about production and marketing and also enhance the efficiency of farm households through the diffusion of best practices across individual members.

Tef (*Eragrostis tef*) is the most important cereal crop serving as the staple food for the majority of Ethiopian people that contributing more to improving food and nutritional security and serving as a source of income for small-holder farmers to cover their expenses. Its cultivation area is expanding from time to time over many years and continued to date[10]. But, the productivity of tef is lower compared to other cereals and its spatial variability across the regions of the country and different zones within the regions is high for different reasons. Among the contributing factors, using low yielding local varieties, drought stress, lodging effects, shattering and poor agronomic practices are reported to be the most significant factors[11]. The existence of such factors significantly affects farmers' efforts to improve production, productivity, income and food security.

According to CSA cited in Nigus *et al.*[1] tef productivity is showing wider spatial variabilities across different regions of the country. For example, during the 2020/21 main production season, the regional average of tef productivity varied from 19.31 quintals per hectare in the Oromia Region to 15.19 quintals per hectare in the Benishangul Gumuz Region. Similarly, there are also spatial variabilities across different zones, in which it varied from 15.84 (in the Southern) to 17.67 quintals per hectares (in the Northern) zones of the Tigray Region, from 10.09 (in Wag Hemra) to 22.65 quintals per hectare (in East Gojjam) zone of Amhara Region, from 15.50 (in East Bale) to 21.26 quintals per hectare (in South-West Shewa) zones of Oromia Region, from 10.53 (in Mao-Komo) to 15.44 quintals per hectare (in Metekel) zones of Benishangul Gumuz Region and from 12.74 (in Segen people) to the 18.10 quintals per hectare (in Sidama) zone of Southern nations and nationalities region.

Based on the information listed above, adoption of the new tef technology may be one of the sources of variation and similarly, there may be income differences between tef technology adopters and no-adopters. Therefore, this research was intended to assess the impact of tef technology adoption on the household income in the study area.

MATERIALS AND METHODS

Description of the study area: The study was conducted in Dendi District, West Shewa Zone, Oromia Regional State, Ethiopia during 2017/18. The District lies between 38°10'54'' East and 9°01'16'' North and is also found at 80 km to the West of the Capital City, Addis Ababa. The District is bordered by Dawo and Wenchi Districts on the South, by Ambo and Ilfata on the West, by Jaldu on the North and by Ejersa Lafo on the East. The District has 79,936.29 hectares of land (39,227.5 cultivated, 14,912.36 grazing, 7,925.93 forest and 14,829.5 uncultivated and 3,041 homestead and others), 38 kebeles (35 rural and 3 urban), 200715 population (42953 urban and 157762 rural), 19231 households (85.6% male and 14.4% female). The mean annual rainfall of the district is 1094 mm (ranging from 750-1170 mm), mean temperature of 16.30°C (ranging from 9.30 to 23.80°C) and mean altitude of 2200 m.a.s.l. Tef, wheat, barley, maize and sorghum are major cereals crops grown in the District[12].

Sampling technique and sample size determination: Multi-stage sampling technique was employed. Dendi district was purposively selected based on its tef production potential. Of 38 kebeles in the District, 24 tef producing kebeles were identified. Then, five kebeles were randomly selected from a total of 24 tef producing kebeles. Finally, a total of 210 sample households were randomly selected. The sample size of 210 was determined using Yamane cited in Adam[13], which can be expressed as follows:

$$n = \frac{N}{1 + N(e^2)} \quad (1)$$

Where:

n = Sample size
N = Population size
e = Level of precision

The sample households from each kebeles were selected using the proportional sampling method of:

$$n_i = \frac{(N_i)(n)}{\sum N_i} \quad (2)$$

n_i = Sample from the ith kebele
N_i = Total population in the ith kebele
$\sum N_i$ = Population of the five sample kebeles
n = Total sample from the district

Data type, source and method of analysis: Both primary and secondary data were used in this research. The primary data was collected from sample households using structured and semi-structured questionnaires. The collected data were analyzed using descriptive, inferential and econometric data analysis methods. Mean, percentage, minimum and maximum were used to report descriptive data analysis. Similarly, the t-test and chi-square test were used to infer the mean difference of descriptive data analysis. For econometric data analysis, the propensity score matching method and logistic regression model were employed.

In a quasi-experiment, the independent variables are manageable, but the problem is selection bias as program participants were not randomly selected to the conditions. In such cases, the propensity score matching method can be used to reduce selection bias. The propensity score is the probability of taking treatment and it controls the selection bias of the included independent variables, while not controlling the variables not measured (unobserved bias). It represents the included variables by a single value, which is a propensity score value.

Statistical analysis: Propensity scores can be estimated using different statistical methods. Logistic regression is the most frequently used method. In this method, estimation of the propensity score is done using logistic regression. The logistic regression model can be expressed as follows[14]:

$$P_i = \frac{1}{1 + e^{-(\beta_o + \beta_i X_i)}} \quad (3)$$

Where:

P_i = Probability of adopting the technology for the ith participant
β_i = Are the model parameters
X_i = Vector of the explanatory variable

The equation of the probability of adoption can be simplified as:

$$P_i = \frac{1}{1 + e^{-z_i}} \quad (4)$$

Using the probability of adoption, the probability of non-adoption can be derived as:

$$1 - P_i = \frac{1}{1 + e^{z_i}} \quad (5)$$

The odds ratio, the ratio of the probability of adoption to non-adoption, can also be derived as:

$$\frac{P_i}{1 - P_i} = \frac{\frac{1}{1 + e^{-z_i}}}{\frac{1}{1 + e^{z_i}}} = e^{z_i} \quad (6)$$

Taking the natural logarithm of the odds ratio, it can be further simplified as:

$$L_i = \ln e^{z_i} = \beta_o + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_n X_{ni} + \in \quad (7)$$

Where:

Li = Natural logarithm of the odds ratio in favor of adopting tef technology
β's = Are the parameters to be estimated
X_i's = Are the vectors of explanatory variables
ε = Is the error term

RESULTS AND DISCUSSION

Descriptive results: Access to credit services showed positive and significant relation with households' decision to adopt tef technologies. Table 1 showed that 84% of households having access to credit services are adopters of tef technologies while only 38.5% of households without access to credit were adopters of tef technologies and the chi-square test also revealed that the mean difference was significant at 1%. This result is similar to the one reported by Habtewold[15].

Access to off-farm income also showed a positive relationship with the household decision to adopt tef technologies. According to the result in Table 1, 72% of households having access to off-farm income were adopters of tef technologies, while 60.7 of the households without access to off-farm income were adopters of tef technologies. From the chi-square test, the mean difference is statistically significant at the 10% probability level. This is in line with the finding reported by Milkias and Muleta[16].

According to the result, households having access to extension services are more adopters of tef technologies. As displayed in Table 1, the majority of the sample households 156 (74%) have access to extension services out of which 112 (72%) were adopters of tef technologies. The chi-square test also showed that the mean difference of extension was significantly different at 1% for the adoption of tef technologies. This result is similar to the one reported by Wossen *et al*.[17].

Based on the result in Table 1, 113 (54%) of the sampled households were members of cooperatives, while 97 (46%) were not. This shows that households that are members of cooperatives are more likely to adopt tef technologies. The result of the chi-square test also showed that there is a significant mean difference in the adoption of tef technologies between cooperative members and non-members. This result is similar to the one reported by Wossen *et al*.[17].

According to the result in Table 2, the mean age of non-adopters is 46.5 years, while that of adopters is 41.4. This shows that the age of the household head is negatively

Table 1: Descriptive results for dummy variables by the adoption of tef

Variables	Adoption of tef technologies: No	Yes	Total	X^2
Sex of the household head				
Female	17	21	38	2.3
Male	55	117	172	
Access to credit services				
No	66	105	171	7.6***
Yes	6	33	39	
Access to off-farm income				
No	42	62	104	3.4*
Yes	30	76	106	
Access to extension contact				
No	28	26	54	9.9***
Yes	44	112	156	
Cooperative membership				
No	45	52	97	11.7***
Yes	27	86	113	
Access to information				
No	20	34	54	0.2
Yes	52	104	156	

*,***Significant levels at 10 and 1%, respectively and Source: Own computation from survey data

Table 2: Descriptive results of continuous variables by the adoption of tef

	Adopters		Non-adopters		Combined		
Variables	Mean	Std. dev	Mean	Std. dev	Mean	Std. dev	t-test
Age of the household head	41.4	11.3	46.5	11.1	43.2	11.4	-3.1***
Education status of the head	4.9	3.7	2.8	2.5	4.2	3.5	4.4***
Tef farming experience	20.3	10.4	22.3	10.3	20.9	10.4	1.4
Livestock holding (TLU)	5.9	2.7	4.1	2.1	5.4	2.6	5.1***
Family size (ME)	2.9	1.3	2.8	1.1	2.8	1.2	-0.9
Land owned (hectares)	1.3	0.6	0.9	0.5	1.2	0.6	3.7***
Market distance (KM)	1.1	0.5	1.4	0.6	1.2	0.5	-3.3***
Distance from FTC (min)	17.7	16.6	21.5	16.9	19.0	16.7	-1.6*

*,***Significance levels at 10 and 1%, respectively and Source: Own computation from survey data

Table 3: Estimation of the propensity score for impact assessment

Adoptions	Coefficients	Standard error	t-value	p-value
Sex of the head	0.217	0.477	0.46	0.649
Age of the head	-0.126	0.041	-3.04	0.002
Education of head	0.058	0.067	0.88	0.380
Family size (ME)	-0.061	0.134	-0.46	0.648
Farm experience	0.106	0.046	2.32	0.021
Livestock holding (TLU)	0.159	0.102	1.55	0.120
Land owned	0.372	0.393	0.95	0.343
Access to information	0.044	0.393	0.11	0.911
Coop membership	0.031	0.420	0.07	0.941
Market distance	-0.412	0.363	-1.14	0.256
Distance from FTC	-0.006	0.012	-0.49	0.625
Off-farm income	0.923	0.407	2.27	0.023
Extension contacts	0.840	0.421	2.00	0.046
Credit access	0.504	0.530	0.95	0.342
Constant	1.888	1.302	1.45	0.147
Mean dependent variables	0.656	SD dependent variable	0.476	
Pseudo r-squared	0.223	Number of observations	209.000	
Chi-square	41.529	Prob>chi2	0.000	

Source: Own computation from survey data

related to the household's decision to adopt tef technologies and the mean difference is statistically significant at a 1% significance level. This result is similar to the one reported by Shita *et al.*[18].

The educational status of the household head is positively and significantly related to the adoption of tef technologies. From the result in Table 2, the mean educational level for adopters was 4.9 schooling years, while that of non-adopters was 2.8 schooling years. The t-test also showed that the mean difference was statistically significant at 1% probability. This result is similar to the findings reported by Jaleta *et al.*[19].

Livestock holding also positively and significantly affected households' decision to adopt tef technologies. According to this result, the mean livestock holding for adopters and non-adopters were 5.9 and 4.1, respectively. This is to mean that households having a greater number of livestock tend to adopt tef technologies compared to those households having a smaller number of livestock. The t-test result showed that the difference is statistically significant at 1% probability. This result is in line with the finding reported by Ayenew *et al.*[20].

Land ownership is positively related to sample households' tef technology adoption decisions, to means that household heads having larger land sizes are more likely to adopt tef technologies compared to those household heads owning less land. From the result in Table 2, the tef technology adopters own 1.3 ha of land while those non-adopters own 0.9 ha. The t-test result also revealed that the mean difference was statistically significant at 1%. This is contrary to the finding reported by Ayenew *et al.*[20].

Distance from the main market and distance from farmers' training centre both showed negative and significant relation with households' decision to adopt tef technologies. Table 2 showed that the mean distance from the market and farmers' training centre was 1.1 km and 17.7 min, respectively for adopters, 0.5 km and 16.6 min for non-adopters. From this result, households living nearer to the main market and farmers' training centre are more likely to adopt tef technologies. The t-test result also revealed that the mean difference was significantly different for both. This result is similar to the one reported by Zegeye[21].

Econometric results: Before going for the econometric model, Variance inflation factor (VIF) and multicollinearity tests were done. The results of both tests confirmed there were no problems with multicollinearity. Therefore, an estimation of the propensity score was done and the result is presented in Table 3.

Age of the head, farming experience, access to off-farm income and access to extension contact were the variables significantly affected households' decision to adopt tef technologies. Farming experience, access to off-farm income and access to extension contact positively and significantly affected households' decision to adopt tef technology, while the age of the household head negatively and significantly households' decision to adopt tef technology.

Using the estimated propensity score, the common support region was restricted. According to the result in Table 4, the common support region is the region between 0.0759814 and 0.9219624. Based on this result, 33 households, (3 non-adopters and 30 adopters) were excluded from the model as they were out of the common support.

The estimated propensity score can also be visualized as presented in Fig. 1. The propensity score values greater than 0.0179827 and less than 0.0759814 were the values excluded from the control group as it is not in the region of common

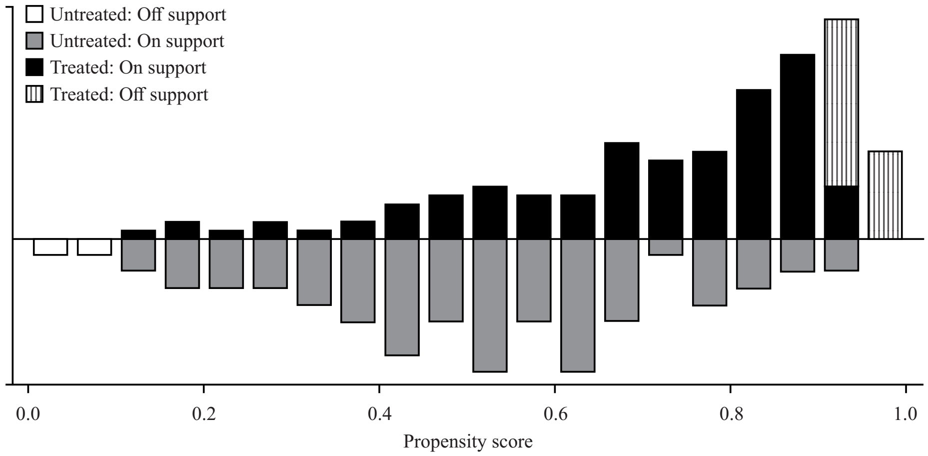

Fig. 1: Propensity score for adopters and non-adopters on and off support region

Table 4: Restriction of the common support region

Variable	Observation	Mean	Standard deviation	Minimum	Maximum
P score (0)	72	0.482196	0.2337602	0.0179827	0.9219624
P score (1)	137	0.7465831	0.1990134	0.0759814	0.9871869

Source: Own computation from survey data

Table 5: Choosing the matching algorithm

Matching methods	Matched samples	Balanced variables	Pseudo R^2
Nearest neighbor matching			
Nearest neighbor (1)	178	10	0.060
Nearest neighbor (2)	178	14	0.038
Nearest neighbor (3)	178	14	0.008
Nearest neighbor (4)	178	14	0.011
Caliper matching			
Caliper (0.01)	77	14	0.103
Caliper (0.10)	108	14	0.030
Caliper (0.25)	120	14	0.087
Caliper (0.50)	129	5	0.495
Radius matching			
Radius caliper (0.01)	134	13	0.049
Radius caliper (0.10)	178	14	0.012
Radius caliper (0.25)	178	14	0.022
Radius caliper (0.50)	178	11	0.084
Kernel matching			
Kernel bandwidth (0.01)	134	12	0.056
Kernel bandwidth (0.10)	178	14	0.013
Kernel bandwidth (0.25)	178	14	0.012
Kernel bandwidth (0.50)	178	12	0.050

Source: Own computation from the survey result

support and the values of the propensity score that is greater than 0.9219624 and less than 0.9871869 were excluded from the treatment group as it is not in the region of common support.

After the restriction of the common support region, choosing the best matching algorithm was done using nearest neighbor matching, caliper matching, radius matching and kernel matching as presented in Table 5.

From the four matching algorithms tested, the nearest neighbour matching of the third neighbour showed good matching properties (smallest value of pseudo-R-square (0.08), all covariates balanced (14) and the largest number of observations matched (178)) compared to other methods and chosen for this specific study.

A balancing test was also conducted to check the matching quality. After a matching is done, there should not

Table 6: Covariates balancing test (testing for matching quality)

Variables	Unmatched matched	Mean Treated	Mean Control	Bias	Reduct |bias| (%)	T-test t	T-test p>|t|	V (T)/V (C)
Sex of the head	Unmatched	0.84672	0.76389	20.9		1.48	0.141	.
	Matched	0.83333	0.85494	-5.5	73.9	-0.44	0.663	.
Age of the head	Unmatched	41.212	46.528	-47.8		-3.28	0.001	1.02
	Matched	42.444	42.855	-3.7	92.3	-0.29	0.771	1.42
Education of the head	Unmatched	4.9927	2.8333	67.7		4.39	0.000	2.29*
	Matched	4.1481	4.0216	4.0	94.1	0.32	0.750	2.24*
Family size ME	Unmatched	2.9504	2.7889	13.8		0.92	0.357	1.38
	Matched	2.9657	2.9926	-2.3	83.4	-0.17	0.864	1.51*
Farm experience	Unmatched	20.153	22.333	-21.1		-1.45	0.149	1.01
	Matched	20.88	21.111	-2.2	89.4	-0.17	0.866	1.10
Livestock TLU	Unmatched	5.989	4.1317	76.7		5.09	0.000	1.59*
	Matched	5.4617	5.3935	2.8	96.3	0.22	0.825	1.74*
Land owned	Unmatched	1.2971	0.98958	55.8		3.73	0.000	1.45*
	Matched	1.2046	1.1684	6.6	88.2	0.51	0.609	1.35
Access to info	Unmatched	0.75182	0.72222	6.7		0.46	0.644	.
	Matched	0.74074	0.76543	-5.6	16.6	-0.42	0.676	.
Cooperative membership	Unmatched	0.62044	0.375	50.4		3.46	0.001	.
	Matched	0.53704	0.5216	3.2	93.7	0.23	0.821	.
Market distance	Unmatched	1.1153	1.3494	-45.5		-3.23	0.001	0.66*
	Matched	1.1817	1.1709	2.1	95.4	0.16	0.871	0.79
Distance from FTC	Unmatched	17.708	21.583	-23.1		-1.59	0.113	0.97
	Matched	18.065	18.972	-5.4	76.6	-0.43	0.670	1.67*
Off-farm income	Unmatched	0.55474	0.41667	27.7		1.90	0.058	.
	Matched	0.46296	0.54012	-15.5	44.1	-1.13	0.259	.
Extension contacts	Unmatched	0.81022	0.61111	44.8		3.19	0.002	.
	Matched	0.76852	0.75309	3.5	92.2	0.26	0.792	.
Credit access	Unmatched	0.24088	0.08333	43.6		2.82	0.005	.
	Matched	0.16667	0.17593	-2.6	94.1	-0.18	0.858	.

*If variance ratio outside (0.71, 1.40) for unmatched and (0.68, 1.46) for matched and Source: Own computation from survey data

Table 7: Joint significance test for covariate balancing

Samples	Pseudo R^2	LR chi^2	p>chi^2	Mean bias	Med bias	B	R	Variables (%)
Unmatched	0.223	60.15	0.000	39.0	44.2	121.8*	1.04	50
Matched	0.008	2.33	1.000	4.6	3.6	20.7	1.53	50

*If B>25%, R outside (0.5, 2) and Source: Own computation from survey data

Table 8: Estimation of average treatment effect (ATT)

Variable	Samples	Treated	Controls	Difference	Standard error	T-stat
Income	Unmatched	38742.38	25296.81	13445.57	2683.48	5.01
	Matched	38880.46	30937.38	7943.100	4824.40	1.65

be a significant difference between the group (treatment and control). Table 6 confirmed that there is no significant difference between treatment and control after matching that making ease of comparison between participants and non-participants.

The joint significance test in Table 7 was our guarantee that we can estimate the average treatment effect on the treated since the pseudo R^2 reduced from 0.223 to 0.008, the likelihood ratio reduced from 60.15 to 2.33 and the mean bias also reduced from 39.0 to 4.6.

Finally, the average treatment effect on the treated (ATT) was estimated. The result in Table 8 revealed that the average treatment effect was 7943 Birr. According to this result, households who were adopters of tef technology earn 7943 Birr more income on average compared to household heads that are not adopters of teff technology. The t-test result also showed that the mean income difference for adopters and non-adopters is statistically significant at a 5% probability level.

To check whether the estimated average treatment effect was the pure effect of the adoption of tef technologies, a sensitivity analysis was conducted. The result proved that the estimated treatment effect was the pure effect of tef technology adoption as it was insensitive to unobservable bias if the gamma value increased to 3.

CONCLUSION

Based on the result of this research, household heads who adopted high yielding improved tef technologies earned a higher income of 7943 Birr than non-adopter household heads on average. From the t-test result, the mean income difference between adopters and non-adopters was statistically significant. Therefore, the adoption of tef technologies significantly improves the household income in the study area.

SIGNIFICANCE STATEMENT

This study discovered that the adoption of high yielding improved tef varieties directly contributes to improving household income and indirectly contribute to reducing spatial variability of tef production and productivity that prevails within and across different regions of the country.

REFERENCES

1. Nigus, M., H. Shimelis, I. Mathew and S. Abady, 2022. Wheat production in the highlands of Eastern Ethiopia: Opportunities, challenges and coping strategies of rust diseases. Acta Agric. Scand. Sect. B-Soil Plant Sci., 72: 563-575.
2. Cheng, A., S. Mayes, G. Dalle, S. Demissew and F. Massawe, 2017. Diversifying crops for food and nutrition security-A case of teff. Biol. Rev., 92: 188-198.
3. Assefa, K., S. Chanyalew, Y. Genet, M. Asfaw and T. Fikre *et al*., 2017. Tef (*Eragrostis tef*) variety Kora. Ethiopian J. Agric. Sci., 27: 137-140.
4. Spaenij-Dekking, L., Y. Kooy-Winkelaar and F. Koning, 2005. The Ethiopian cereal tef in celiac disease. N. Engl. J. Med., 353: 1748-1749.
5. Assefa, K., J.K. Yu, M. Zeid, G. Belay, H. Tefera and M.E. Sorrells, 2011. Breeding tef [*Eragrostis tef* (Zucc.) trotter]: Conventional and molecular approaches. Plant Breed., 130: 1-9.
6. Baye, K., 2014. Teff: Nutrient Composition and Health Benefits. International Food Policy Research Institute (IFPRI), Washington, D.C. Addis Ababa, Ethiopia, Pages: 20.
7. Alaunyte, I., V. Stojceska, A. Plunkett, P. Ainswaorth and E. Derbyshire, 2012. Improving the quality of nutrient- rich teff (*Eragrostis tef*) breads by combination of enzymes in straight dough and sourdough breadmaking. J. Cereal Sci., 55: 22-30.
8. Tsegay, A., E. Vanuytrecht, B. Abrha, J. Deckers, K. Gebrehiwot and D. Raes, 2015. Sowing and irrigation strategies for improving rainfed tef (*Eragrostis tef* (Zucc.) Trotter) production in the water scarce Tigray Region, Ethiopia. Agric. Water Manage., 150: 81-91.
9. Negash, W., A. Menzir and M. Kassaye, 2017. Effect of row spacing on yield and yield components of teff [*Eragrostis tef* (Zucc.) Trotter] varieties in Gonji Kolela District, North Western Ethiopia. J. Biol. Agric. Healthcare, 7: 35-43.
10. Chanyalew, S., S. Ferede, T. Damte, T. Fikre and Y. Genet, 2019. Significance and prospects of an orphan crop tef. Planta, 250: 753-767.
11. Assefa, K., G. Cannarozzi, D. Girma, R. Kamies and S. Chanyalew *et al*., 2015. Genetic diversity in tef [*Eragrostis tef* (Zucc.) Trotter]. Front. Plant Sci., Vol. 6. 10.3389/fpls.2015.00177.
12. Getahun, A. and G. Muleta, 2021. Adoption of improved *tef* varieties in Central Ethiopia: A double-hurdle model. Int. J. Agric. Biosci., 10: 140-146.
13. Adam, A.M., 2020. Sample size determination in survey research. J. Sci. Res. Rep., 26: 90-97.
14. Gujarati, D.N. and D.C. Porter, 2009. Basic Econometrics. 5th Edn., McGraw-Hill Irwin, New York, USA, ISBN: 9780071276252, Pages: 922.
15. Habtewold, T.M., 2018. Adoption and Impact of Improved Agricultural Technologies on Rural Poverty. In: Economic Growth and Development in Ethiopia, Heshmati, A. and H. Yoon (Eds.), Springer, Singapore, pp: 13-38.
16. Milkias, D. and G. Muleta, 2021. Economic analysis of factors influencing adoption of barley HB1307 variety in Western Shewa highlands: The case of Elfeta District. Int. J. Agric. Biosci., 10: 94-100.
17. Wossen, T., A. Alene, T. Abdoulaye, S. Feleke and V. Manyong, 2019. Agricultural technology adoption and household welfare: Measurement and evidence. Food Policy, Vol. 87. 10.1016/j.foodpol.2019.101742.
18. Shita, A., N. Kumar and S. Singh, 2020. The impact of agricultural technology adoption on income inequality: A propensity score matching analysis for rural Ethiopia. Int. J. Inf. Decis. Sci., 12: 102-114.
19. Jaleta, M., M. Kassie, P. Marenya, C. Yirga and O. Erenstein, 2018. Impact of improved maize adoption on household food security of maize producing smallholder farmers in Ethiopia. Food Secur., 10: 81-93.
20. Ayenew, W., T. Lakew and E.H. Kristos, 2020. Agricultural technology adoption and its impact on smallholder farmer's welfare in Ethiopia. Afr. J. Agric. Res., 15: 431-445.
21. Zegeye, M.B., 2021. Adoption and ex-post impact of agricultural technologies on rural poverty: Evidence from Amhara Region, Ethiopia. Cogent Econ. Finance, Vol. 9. 10.1080/23322039.2021.1969759.