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Impact of farmer training on potato yield: a case of smallholder potato farmers in Malawi

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Due to rapid population growth, agri-food systems have been under increasing pressure to adapt and innovate to sustainably meet the growing demand for food. This requires advances in agricultural practices, technology and distribution networks. Farmer training has been proven to be a crucial component in this transformative process. Equipping farmers with the necessary knowledge and skills becomes paramount to optimize agricultural productivity while also improving their coping with the effects of climate change. This study applied the difference-in-difference method with inverse probability-weighted regression to analyze the impact of farmer training on potato yield. Results showed that 40% of farmers who received training interventions were members of farmer groups and had more farming experience compared to the control group. Additionally, the annual crop enterprise revenue for training participants was USD 255 compared to USD 134 for the control group. Results also showed that potato farmers who participated in positive selection training reported an increase in yield by 14%. On average, training participants were able to increase their potato yield by 1.33 tons per acre. These findings demonstrate the importance of providing targeted training and specific skills in order to enhance farm output. Furthermore, improving access to credit and supporting effective participation in farmer groups would increase farm yields.

KEYWORDS

seed potato, farmer training, difference in difference model, yield, positive seed selection

Introduction

Irish potato is an important food security root crop in Sub-Saharan Africa (SSA). It is rich in vitamin C, B6, niacin, phosphorus, and manganese. Potato is crucial in Malawi, serving as a significant source of both sustenance and revenue for farmers. They rank as the third most essential food crop, following maize and cassava, and play a pivotal role as the primary income source in key production areas (Kapalasa et al., 2022). Potato production in the SSA region is largely carried out by small and medium-sized producers (Harahagazwe et al., 2018). This sub-sector faces a myriad of challenges that arise from, among others, limited access to high-quality potato seeds and climate variability (Schulte-Geldermann, 2017). The latter is marked by unpredictable rainfall patterns and temperature fluctuations, which exacerbate the outbreak and rapid spread of pests and diseases. Farmers struggle to manage these challenges due to a lack of resources and knowledge.

The repercussions of these obstacles extend beyond reduced yields, affecting the economic viability of potato farming and the livelihoods of those involved in the sector. For instance, Wei et al. (2017) noted that pest and disease infestation leads to substantial decreases in crop yields of approximately 80%. Additionally, findings from Wang et al. (2023) showed that bacterial wilt pathogen causes damage to about 20–60% and sometimes may be severe up to 80%. Such declines can pose severe economic challenges for farmers, particularly in areas where potatoes are a crucial source of sustenance and household income. On-farm training can, however, be leveraged to improve agricultural practices and knowledge transfer, possibly contributing to increased production and sustainable farming methods (Davis et al., 2012).

Various factors ranging from pests such as late blight (*Phytophthora infestans*) and bacterial wilt (*Ralstonia solanacearum*) and other farm and farmer characteristics affect crop yields have been highlighted as key issues (Damtew et al., 2018). Limited access to clean planting materials is still a major constraint to successful potato production in Malawi as most farmers source their seed from uncertified sources (Kapalasa et al., 2022). The repeated use of contaminated seed stocks can result in the accumulation of pests and diseases in the communities causing a significant decline in crop yields. Further, changes in soil pH make potatoes susceptible to various soil-borne diseases (Munthali et al., 2021). Together, these factors have led to a stagnation in potato yield. It is estimated, for instance, that the average potato yield is 18 tons per hectare as opposed to a potential of about 40 tons per hectare (FAOSTAT, 2023).

The role of agricultural training in boosting productivity is well-documented in the literature. In recent years, various governmental and non-governmental organizations have implemented training programs tailored to the needs of smallholder farmers. These initiatives often use participatory methods, such as farmer field schools (FFS) and demonstration plots, to ensure that farmers can observe and practice new techniques before adopting them. For instance, a study in Kenya found that potato farmers who participated in training programs achieved yield increases of up to 40% compared to untrained farmers (Kamau et al., 2020).

Beyond yield improvements, training enhances farmers' understanding of market dynamics and value addition. This knowledge enables them to access better markets and negotiate favorable prices for their produce (Nakano et al., 2018). Moreover, training programs that include components of financial literacy empower farmers to make informed investment decisions, further boosting their productivity and income. The combined effect of these benefits is an improvement in the socio-economic wellbeing of farming households. Similarly, Gebrehiwot et al. (2019) found that farmer training programs directly correlate with better crop management practices, which are essential for sustainable agriculture in resource-constrained environments.

A survey by the International Potato Center (2009), identified various challenges in potato production. First, it highlighted that the productivity of the crop was exceptionally low, primarily due to farmers' reliance on low-quality tubers, which significantly hindered yield potential. Second, the varieties being cultivated by farmers were not aligned with market preferences, as they lacked the processing qualities required for value-added products. These observations underscore the need for targeted interventions to improve seed quality and promote the adoption of market-preferred varieties to enhance productivity and profitability in the sector.

Following the aforementioned challenges, the CIP through financial support from the Irish Aid launched a potato project that aimed at revitalizing seed and table potato production to increase productivity, food availability, and incomes of smallholder Irish potato farmers through the utilization of improved technologies. In the first phase, smallholder potato farmers in the selected districts (Dedza, Mchinji, Ntcheu, and Ntchisi) were trained on positive seed selection and small plot techniques. Additionally, research personnel from the Department of Agricultural Research Services (DARS) received training on seed production and crop management.

Two main interventions were provided to farmers; positive selection and small plot technique. Such on-farm training and practices such as plant selection can help in reducing seed degeneration, and result in improved on-farm maintenance of seed quality. For instance, the positive selection technique entailed various steps. First, farmers mark healthy-looking plants when the crop is still green. Secondly, the marked plants were inspected to unmark plants that show disease-related symptoms. Lastly, during harvest, the marked plants were harvested separately and tubers were inspected for the presence of symptoms of seed-borne diseases. Seed tubers were retained only from plants that did not show tuber symptoms at harvest. The small plot technique is based on the concept that farmers should be able to have a small plot free from soil-borne on their farm that has not been planted with potato hence suitable for production of clean seed (Obura et al., 2014).

Although training interventions are widely recognized as crucial for mitigating tuber-borne diseases like bacterial wilt and virus-related infections, there remains a significant knowledge gap regarding their direct impact on potato yields, particularly in the Malawian context. Existing research including Kapalasa et al. (2019) and Maganga (2012) has largely focused on the technical and adoption aspects of potato production, leaving a void in understanding how farmer participation in on-farm training translates into measurable productivity gains.

According to Baker (2000), various impact evaluation designs have been used to overcome the self-selection bias problem. One major advantage of the Difference in Difference (DiD) model is to remove biases coming from permanent differences between treated and control groups and also before and after. The current study adopts DiD with inverse probability weighting (IPW) as it ensures robust causal inference by accounting for selection bias and balancing observed covariates between treatment and control groups to quantify the impact of the given intervention.

This study addressed this gap by assessing if farmers who participate in training programs achieve higher potato yields than their non-participant counterparts. To test this, the study employed the DiD method to assess the impact of training interventions by comparing yield outcomes between trained and untrained potato farmers.

Methodology

Study design and sampling procedure

The study used two waves of panel data gathered from a survey of potato households through a semi-structured questionnaire by CIP. A

baseline survey was conducted in 2012 to document the households' socioeconomic status before introducing the potato training intervention. A multistage sampling technique was used for the baseline survey. Four main Irish potato districts, Ntcheu, Dedza, Ntchisi, and Mchinji, were purposively selected in the first stage. In the second stage, two extension planning areas (EPAs) from each district were purposively selected due to their high number of farmers growing potatoes. In the third stage, the probability proportionate to size method was used to select the number of villages drawn per EPA resulting in 20 villages. Lastly, 15 households were randomly selected per village leading to a total of 300 households.

After implementing the training intervention, CIP conducted an end-line survey of the same households in 2017. Like in the baseline survey, a multistage sampling approach was used to select the respondents. The first step involved purposively selecting three of the districts with high potato production (Ntcheu, Dedza, and Dowa). In the second stage, two EPAs per district were selected. In the third stage, two sections were chosen from each EPA, and in the fourth stage, two villages were selected from each section. Lastly, 15 households were randomly drawn from each of the 24 villages resulting in 360 households.

For the analysis in this paper, only Dedza and Ntcheu were used since both districts were part of both phases of data collection; baseline and endline. The study sites are shown in Figure 1.

Due to attrition (migration or death of respondents) and incomplete questionnaires across the two survey phases, the study utilized unbalanced panel data, comprising 156 households in 2012 and 107 households in 2017.

Conceptual framework

The conceptual framework in Figure 2 shows the linkage between donor-funded training, market participation with the farmer, and farm characteristics and institutional factors. The framework begins from the point that socio-economic determinants such as household education level, farm size, age, gender, household size, and farming experience affect farmers' participation in training and hence influence access and uptake of new technologies and information (Osmani and Hossain, 2015). This influences the yield level a farmer can be able to produce. When a farmer participates in on-farm potato training the benefits that trickle down include increased potato yield, better knowledge of production, reduction in poor-quality produce. All these benefits will lead to increased household incomes, and improved food security hence leading to improved livelihoods.

Data collection

Panel dataset from two surveys implemented by CIP, Malawi in August 2012 and August 2017 was used. The data were collected through a semi-structured questionnaire. The information collected from respondents included household demographics, farm, and household assets, crop produced and inputs used, marketing and price information, sources of household income (both farm and non-farm income), challenges in marketing, extension service provision, farmer organization, food security shocks and household dynamics. The data was collected through face-to-face interviews.

Empirical data analysis

In order to evaluate the impact of potato training on yield, this study used the DiD method as specified below:

$$Y_{it} = a + \beta_1 Post_t + \beta_2 Treat_i + \beta_3 Post_t * Treat_i + \varepsilon \quad (1)$$

where Y_{it} is the outcome variable of interest (potato yield) for respondent i at period t (where $t = 0$ and $t = 1$ for baseline and follow-up surveys, respectively), $Post_t$ is a year dummy variable that takes a value of one for the follow-up data, and zero for the baseline data, $Treat_i$ is the treatment dummy with values of 1 for the treatment group and 0 for control groups. The interaction term given by $Post_t * Treat_i$ in Equation 1 represents the impact of the intervention. The DiD method is most appropriate to analyze changes in two groups over two time periods when both groups are not treated in period 1 while only one of the groups is treated in period 2 (Schwerdt and Woessmann, 2020). For example, in the current study, no farmer received training in the baseline period (2012), while in the end-line data of 2017, some farmers had received training.

The first step in data analysis involved determining the relevant sample size of the analysis due to attrition. Following Outes-Leon and Dercon (2008), the study estimated a probit model in which the dependent variables take the value one for households that drop out of the sample after the first wave and zero otherwise. Explanatory variables are baseline values for all variables that are believed to affect the outcome variable of interest. Results showed a pseudo R-squared of 7% which can be interpreted as the proportion of attrition that is non-random. Based on the results the study proceeded using the inverse probability weighting approach in the DiD model to control for attrition bias (Wooldridge, 2002).

Description of variables used in analysis

The variables included in the analysis are presented in Table 1. The age of a household head is hypothesized to have both a negative and positive impact on the quantity of potatoes produced. The age of the household head determines the labor supply in terms of potato production. Additionally, age determines whether a household will adopt new technologies or not. For instance, a young household head may adopt new technology due to exposure and also tends to cultivate larger farms compared to the older household head. Findings from Lindsjö et al. (2021) in Malawi showed that older farmers did not adopt new methods of farming, lacked energy, and hence resulting in low production.

The sex of the household head has an impact on the quantity produced. According to Gebre et al. (2021), male-headed households were found to produce more maize compared to their female counterparts. Female-headed households are deemed to have limited access to productive resources like land and are time-constrained by reproductive roles and domestic chores. The study hypothesized that the sex of the household head positively influenced the potato yield. Additionally, the more experience a farmer has in the subsector, the more he or she becomes knowledgeable and hence able to minimize risks and maximize opportunities for greater outcomes. Kwambai et al. (2023) found that experienced farmers have more knowledge on how to produce

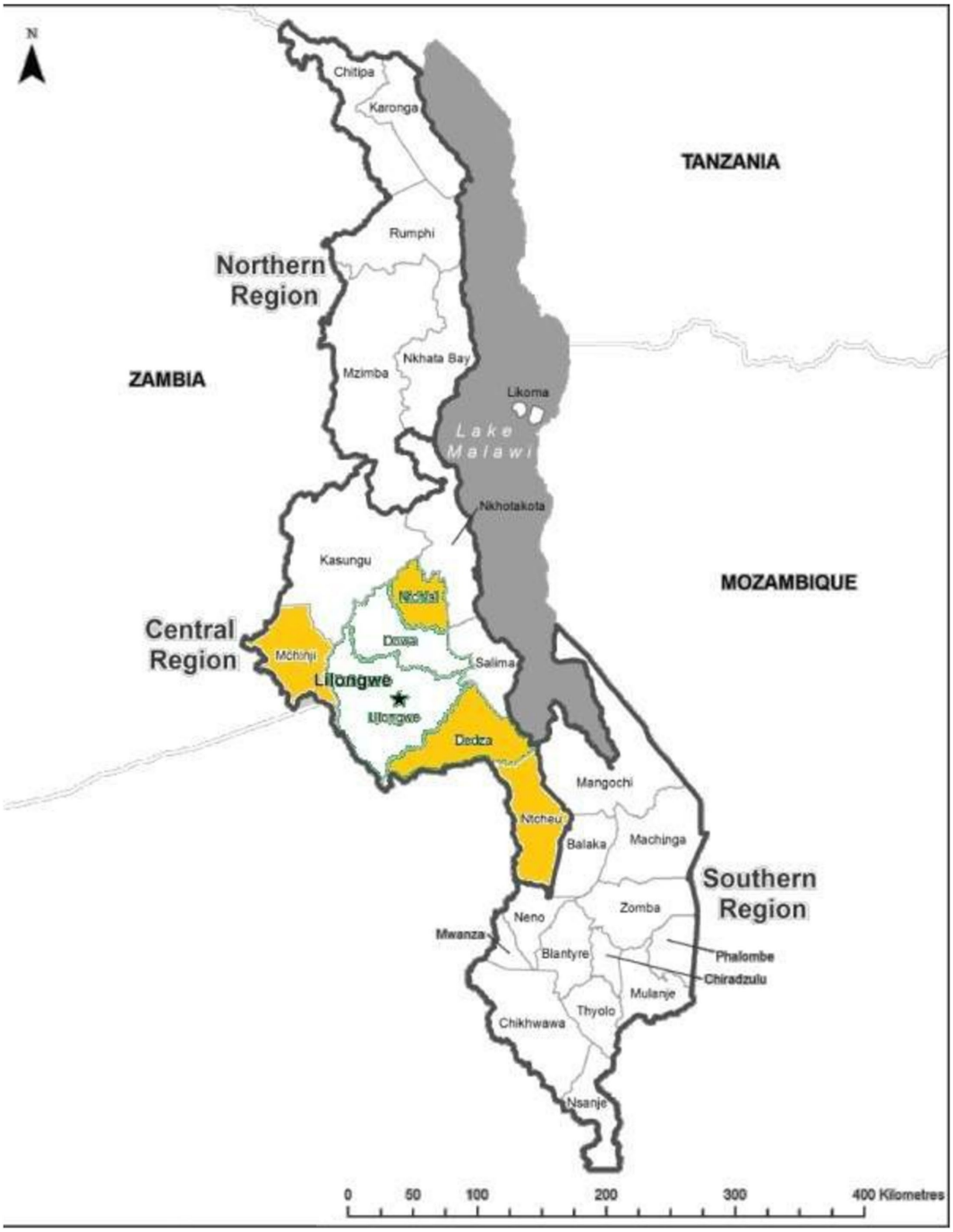

FIGURE 1
Map of the study sites in Malawi.

hence leading to increased yield. Therefore, this study hypothesized that farming experience has a positive impact on potato yield.

Household size was hypothesized to have both negative and positive effects on total potato yield. Larger households will mean higher availability of labor supply for farm production and hence more yield. Alternatively, a larger household size also implies land fragmentation leading to small parcels of land for production and hence negatively impacting the total yield. This is consistent with the findings of Okello et al. (2019) on rice production. Land being an important factor of production, it was hypothesized that an increase in farm size increases the level of potato production. Therefore, the study hypothesizes a positive relationship between household farm size and total yield. Yassin (2017) found that farm size positively influenced potato yield in Ethiopia.

In this study, it was hypothesized that ownership of livestock positively impacts potato yield. Ownership of livestock is a form of household wealth indicator. Livestock also provides inputs such as manure for farm production and animal power for farm tillage, sowing, and weeding. Komarek and Msangi (2019) showed that livestock manure serves as an additional source of nitrogen for crop growth and thus helps to reduce yield gaps.

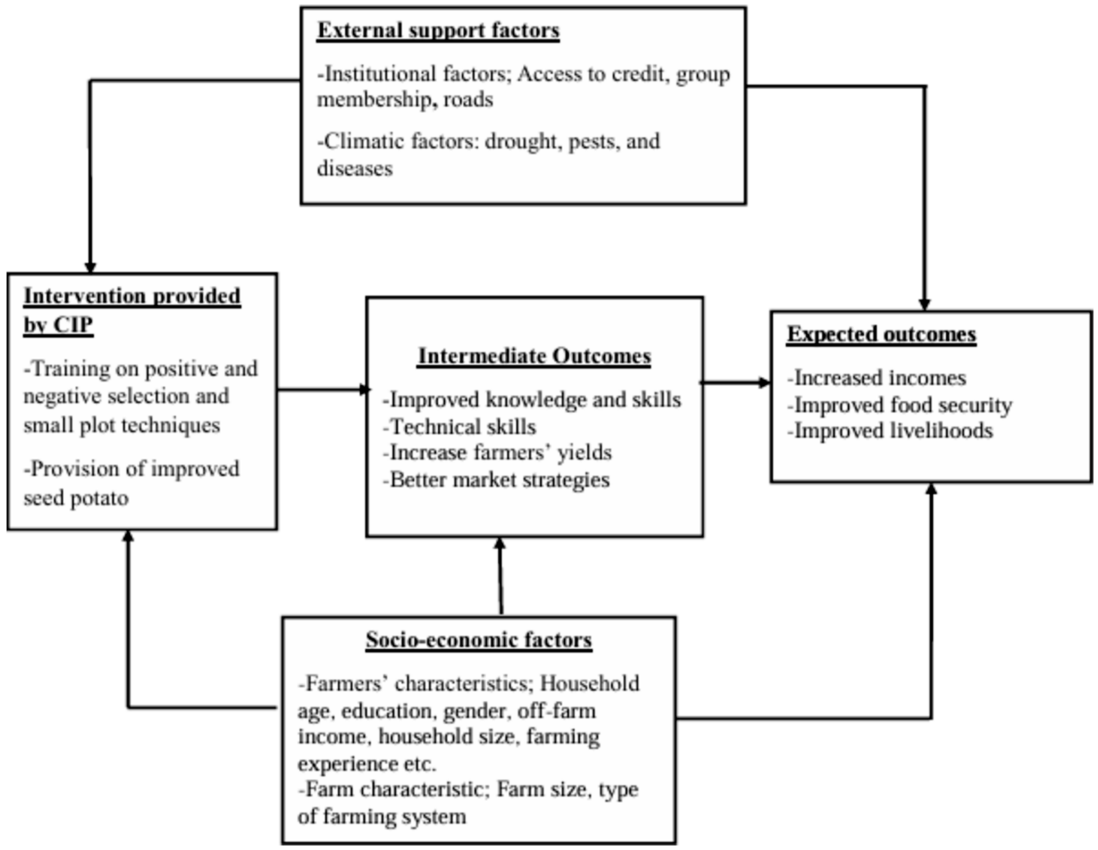

FIGURE 2
Conceptual framework.

TABLE 1 Explanatory variables and their expected signs.

Variable	Description	Expected sign
Household head age	Age of household head in years	+
Sex of household head	Gender of the household head (1 = male 0 = female)	+
Farming experience	Years engaged in potato production	+
Household size	Number of people who normally reside in a household	+/−
Total land size	Farm size owned by household in acres	+
Tropical livestock units	Total number of livestock owned by household	+
Agricultural credit access	Access to agricultural credit (1 = yes, 0 = no)	+
Used of irrigation system	Farmers who used irrigation system (1 = yes, 0 = no)	+
Group membership	% of farmers who are members of an agricultural group (1 = yes, 0 = no)	+

Access to credit by farmers helps them purchase required inputs and also be able to source labor required for potato production. According to Salima et al. (2023), access to credit positively influences the quantity of produce by households and hence improves household food security in Malawi. The study hypothesized that access to credit would have a positive relationship with potato yield.

Group membership was used as a proxy for a household's access to social capital. In this study belonging to a farmer group was hypothesized to positively influence farmers' potato yield. According to Addai et al. (2022), membership in farmers' organizations could significantly impact farm household head's decision to adopt new technologies and interventions, which potentially enhance crop productivity.

Results and discussion

Socio-economic and farm characteristics

Table 2 summarizes the key socio-economic characteristics of potato farmers. Male-headed households were more likely to participate in the training than female heads. This can be a result of culture and beliefs, norms, and community practices that limit women from attending such training. Snider et al. (2023) showed that women could not attend trainings that were held outside their village as this would interfere with meal preparation and childcare.

The number of years a household had participated in potato production was statistically significant at 10 and 5% levels for positive seed selection and small plot technique groups, respectively. On

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TABLE 2 Socio-economic characteristics of treated and control group.

Variable	Participants			Non-participants			
	Positive selection only (PS) (n = 67)	Small plot technique only (SPT) (n = 31)	Combination (PS + SPT) (n = 58)	Control group (n = 107)	Test of difference between participants in the positive selection, small plot size technique, and control group		
					[a-b]	[a-c]	[b-c]
Household head age (years)	43.25	42.58	43.91	36.93	0.24	−0.25	−0.42
	(13.69)	(11.63)	(15.30)	(12.86)			
Education level (years)	5.06	4.68	5.02	5.65	0.56	0.07	0.45
	(3.20)	(3.00)	(3.60)	(3.22)			
Sex of household head (male)	0.85	0.74	0.72	0.87	1.29	1.75**	0.18
	(0.36)	(0.44)	(0.45)	(0.33)			
Number of household size	5.23	5.42	5.52	4.57	−0.44	0.84	−0.22
	(1.86)	(2.06)	(1.90)	(1.62)			
Farming experience (years)	10.34	13.35	14.84	9.23	−1.72*	2.57**	−0.66
	(8.30)	(7.48)	(11.24)	(8.82)			
Land size (acres)	3.24	3.02	3.84	2.95	0.42	−1.28	−1.61
	(2.68)	(1.78)	(2.51)	(1.79)			
Annual revenue from other crop enterprise (USD)	192.01	98.97	255.23	134.83	1.85**	−0.91	−1.76*
	(268.65)	(110.75)	(486.26)	(240.23)			
Total livestock revenue (USD)	381.08	318.95	453.36	245.00	0.38	−0.51	−0.83
	(805.25)	(633.30)	(767.62)	(412.20)			
Annual non-farm income (USD)	301.86	134.48	121.98	112.47	0.86	1.26	0.28
	(1074.46)	(201.34)	(201.42)	(303.04)			
Group membership (Dummy)	0.66	0.39	0.40	0.13	2.57**	2.99	−0.09
	(0.47)	(0.50)	(0.06)	(0.34)			
Access to agricultural credit (Dummy)	0.07	0.26	0.16	0.08	−2.55**	−1.46	1.21
	(0.26)	(0.44)	(0.37)	(0.28)			
Distance in the main market (Km)	11.13	18.92	15.31	16.39	−1.38	−0.81	0.40
	(13.70)	(41.84)	(39.71)	(29.70)			

***, **, *Denote statistically significant differences at 1, 5, and 10%, respectively. The letters a, b, c denotes participation in positive selection and small plot size technique, control group, respectively. Standard errors are in parentheses.

average, the farmers who received training had more years in potato farming compared to those in the control group. This implies that more experienced farmers seek more information through training to be able to minimize risk and be able to efficiently use resources hence maximizing their profit from potato production.

The findings demonstrate significant economic advantages for farmers who engaged in advanced agricultural training, particularly in potato production. The results depicted a statistically significant difference in training programs combining positive selection and small plot techniques achieved higher revenues from farm enterprises, averaging USD 192 and USD 255, respectively, compared to the control group. These results align with studies emphasizing the role of precision agriculture and improved cultivation practices in enhancing farm incomes (Masi et al., 2022; FAO, IFAD, UNICEF, WFP, and WHO, 2021). Furthermore, farmers who participated in potato training exhibited higher average non-farm incomes (USD 112) compared to the control group (USD 50), suggesting that training may enhance overall income diversification opportunities. This corroborates the findings by Abdallah et al. (2021), who noted that agricultural training can improve farmers' skills, leading to better engagement in off-farm economic activities. Revenue from livestock units also showed notable differences, with participants receiving on average USD 50 compared to USD 28 for non-participants however, it was insignificant in both groups. These results underscore the multifaceted benefits of farmer training, not only in enhancing potato yields but also in improving broader income streams across farm and non-farm activities, thereby contributing to rural economic resilience.

Household income arising from various non-agricultural sources such as wage labor, small businesses, or other economic activities, is intricately linked to an individual's participation in training programs (Ogada et al., 2020). The results show that on average, non-participants (control group) have lowest off-farm income levels compared with those who participated in any kind of potato training. This difference can be attributed to the fact that having a supplemental source of

TABLE 3 Potato yield of farmers across different treatment groups.

Outcome variable	Positive selection (n = 67)	Small plot (n = 31)	PS+ Small plot (n = 58)	Control group (n = 107)	Pooled sample (N = 263)
Average potato yield (Kgs/acre)	2232.78 (5097.82)	530.94 (662.63)	1095.18 (1550.35)	767.06 (1176.19)	1158.12 (2858.11)

Standard deviation in parentheses. PS, positive selection.

income from off-farm activities provides individuals with the financial resources necessary to invest in their own education and skill development.

Notably, more than 60% of farmers who were treated with positive selection were found to belong to farmer groups compared to those who were treated with the small plot technique. This shows that group membership serves as a means of scaling innovation (Pawera et al., 2024). Additionally, results show that 26% of farmers who participated in the small plot technique had access to agricultural credit compared to 8% of farmers who did not participate in any type of training (control group). The results are consistent with the findings of Lelisho and Lelisho (2024) who showed that credit facilitates the timely acquisition of high-quality agricultural inputs and could lead to improved crop yields.

Table 3 shows the difference in means of the outcome variable across the treatment groups and control group. On average, the potato yield was highest for farmers treated with positive seed selection training with approximately 2,232 kg/acre. Farmers who participated in both training had slightly higher yields compared to those who participated in the small plot technique who had the lowest yields. The control group had an average of 767 kg/acre while the pooled sample showed an average of 1,158 kg/acre.

Factors affecting smallholder farmers' potato yield

First, we estimated determinants of potato yield using an ordinary least square regression where the dependent variable was potato yield in kilogram and later performed the DiD model. Results in Table 4 indicate that the age of the household head is negatively correlated with the potato yield. A one-year increase in the age of the household head led to a 3-kilogram decrease in the amount of potato produced and was statistically significant at a 10% level, suggesting that as age increases, farmers prioritize other ventures over farming, which requires a lot of manpower, leading to a fall in overall crop production. Additionally, as farmers grow older, they become risk-averse and are likely not to adopt new technologies leading to a reduction in the overall potato yield. This is contrary to the findings of Manishimwe et al. (2019), which indicated that an increase in the age of potato producers implies an increase in experience in the production of the crop resulting in higher productivity in potato production.

Access to agricultural credit was found to be positive and significant at a 10% level in influencing potato yield. Access to credit helps farmers purchase the required farm inputs such as fertilizer, improved seed, pesticides, and other equipment which help increase crop productivity. The study showed that access to credit increased farmers' yield by 45 kilograms. Assouto and Houngbeme (2023) also showed that farmers with access to credit had higher productivity levels compared to those without in Benin.

TABLE 4 Factors affecting smallholder potato farmers' yield.

Variables	Marginal effect	Std. error	p-value
Household head sex	0.097	0.210	0.643
Household head age	−0.054*	0.030	0.075
Household head age squared	0.001*	0.001	0.085
Access to agricultural credit	0.448*	0.247	0.072
Household head size	0.121**	0.049	0.015
Land size	0.025	0.038	0.517
Belonging in the farmer group	0.280*	0.170	0.100
Farming experience	−0.004	0.100	0.640
Tropical livestock units	−0.237***	0.086	0.006
Use irrigation system	0.286	0.227	0.210

***, **, *Denote statistically significant differences at 1, 5, and 10%, respectively.

As hypothesized household size was found to be positive and significant at a 5% level in influencing potato yield. A larger household is associated with the availability of labor for production therefore leading to an increase in production levels. In the study, an increase in households led to 12 kilograms increase in potato yield. A larger household size provides an opportunity to participate in training since they can be able to distribute their household activities among themselves compared to a smaller household size. These findings are consistent with those of Wassihun et al. (2019).

Belonging to a farmer group was found to increase potato yield by 28 kilograms and was a significant 10% level. Literature has documented membership in farmer groups as a key strategy for improving farm productivity through reduced technical inefficiency in input use (Ainembabazi et al., 2017). Membership in farmer groups leads to increased participation in training and the exchange of knowledge and ideas leading to increased production levels. As indicated by Ikendi et al. (2023), social groups provide social capital and networking for accessing information resources.

Additionally, the number of tropical livestock units had a negative and significant impact on potato yield. This relationship can be attributed to resource competition, as households with larger livestock herds may allocate less labor and land to crop production, relying more on livestock for their livelihoods. This finding corroborates those of Herrero et al. (2016), highlighting that high livestock densities often lead to land degradation, reduced soil fertility, and a diversion of resources like feed and water, which could otherwise support crop cultivation.

Average treatment effects using inverse probability-weighted (IPW) model

Results from the inverse probability weighted model on the impact of training participation on potato yield are presented in Table 5.

TABLE 5 Inverse probability weighted model on the impact of training participation on potato yield.

Outcome variable	Measures	Positive selection (n = 67)		Small plot technique (n = 31)		Combination of PS + small plot technique (n = 58)	
		Coefficient	Robust std. error	Coefficient	Robust std. error	Coefficient	Robust std. error
Potato yield (kgs/acre)	ATE	1328.84***	446.6	131.25	206.49	1323.43***	318.32
	PO mean (non-participants)	1137.56***	299.77	745.77***	160.39	500.44***	88.96

PO means represent potential outcome means. ***, **, *Denote statistically significant differences at 1, 5, and 10%, respectively. PS, positive selection.

Results revealed that the average potato yield of farmers who participated in positive seed selection training would be 1,328 kg/acre compared to 1,137 kg/acre that would be produced if none of the farmers participated in the training and results were significant at 1% level. The average treatment effect as a percentage term showed that the average yield was increased by an estimated 14.4% when every farmer participated in the training relative to the case when no farmers participated in the training.

Positive seed selection training focuses on traits that promote disease resistance, high yield potential, good quality attributes, and adaptability to local conditions. Therefore, selecting potato seeds that exhibit resistance to common diseases such as late blight, early blight, and other diseases can greatly reduce the risk of crop loss and the need for pesticide application hence leading to increased output. Further, farmers being able to choose potato seeds with a proven track record of high yields can increase the productivity of the crop and ensure a better return on investment.

Results from the IPW model revealed that there were differences between farmers who participated in the two trainings (positive selection and small plot approach). Specifically, participants had 1,323 kg/acre compared to 500 kg/acre for non-participants. This represents a 62% increase in yield among trained farmers compared to their untrained counterparts. This big improvement in yield highlights the effectiveness of training programs in enhancing farmers' technical skills and knowledge, particularly in producing high-quality potato seeds, which directly translates to increased productivity. These findings align with recent studies, such as those by Gondwe et al. (2017), which emphasize that farmer training improves crop management practices, leading to higher yields.

By utilizing small plot technique training also, the model estimated a positive net income advantage over non-participants, however the differences were not significant. This can be attributed to the fact that the technique requires a farmer to produce seeds in a confined area where potato crops have not been planted in the previous year or more recently. Further, the small plot technique faced some challenges including a few tubers being multiplied in a given area hence unable to achieve any meaningful impact. In Ntcheu, farmers were more interested in the new varieties rather than being trained in new techniques for seed improvement and multiplication.

Conclusion

This study investigated the effect of various training interventions on potato yield using data collected from potato producers in Malawi. The data was analyzed using a difference-in-difference model, with an inverse probability weighting approach to correct for non-randomness. The result shows that the adoption of a combination of both training interventions (positive selection and small plot technique) had a greater impact on the household potato yield. Additionally, various factors such as household age, access to credit, group membership, household size, and tropical livestock unit were found to significantly influence household potato yield. Therefore, strengthening the provision of institutional services such as credit for farmers can help to increase the adoption and uptake of agricultural technologies and hence increase the overall production levels. Designing interventions that strengthen farmer groups and other institutions such as cooperatives can help to increase social networks hence improving access to relevant information and reducing transaction costs leading to improvements in farm productivity.

Recognizing the significance of participation in targeted farm training, there is a need to strengthen farmer sensitization to participate in on-farm training. Government agencies in collaboration with private sector extension service providers should educate farmers on relevant good agricultural practices that are focused on potato enterprise improvement. Additionally, improving local and or informal seed systems in the production and distribution of high-quality seeds is necessary to minimize reliance on external sources. This can be achieved through establishing centralized seed distribution centers within the communities.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

EdK: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. DO: Supervision, Writing – review & editing. JO: Funding acquisition, Project administration, Resources, Supervision, Writing – review & editing. OM: Project administration, Supervision, Resources, Writing – review & editing. ElK: Project administration, Supervision, Resources, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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