

Original Research Article

Evaluating Agricultural Extension Training and Education as Information-inputs for Maize Productivity in a rural set-up of North-Rift, Kenya

ABSTRACT

Maize (*Zea mays* L.) is an important source of staple food in Kenya. Research innovations and physical inputs, and the capacity of farmers to use them are major ingredients for crop productivity enhancement. This study evaluated agricultural extension training and formal education as elements of farmers' capacity to use innovations and inputs. The study was conducted in a rural setup of North Rift in Kenya. Data were gathered by use of interview schedules through cross-sectional survey from 502 households sampled purposively and by simple random sampling. Welch's *t*-test and Mann-Whitney *U* test were used to test for differences between means. 42.8% of the participants reported that they had not received agricultural extension training, 57.2% had. 65.2% had up to primary level education, 34.8% had secondary and above. Formal education up to primary was regarded as basic. Results indicated that fertilizer-use rates and maize yields differed significantly between groups 'who had received Extension training' and those who 'had not been trained'; $t(482.785) = -9.228, P = .000$ and $t(290.29) = -5.438, P = .000$, respectively. Regarding formal education, fertilizer-use rates and maize yields differed significantly between 'basic education' category and 'higher than basic'; $t(332.28) = -5.699, P = .000$ and $t(290.29) = -5.438, P = .000$ respectively. The alternative Mann-Whitney *U* test showed similar results. Effect sizes as measured by Eta-squared (η^2) ranged from .06 (medium) to .1445 (large). It is concluded that Agricultural extension training had a highly significant influence on maize productivity. Formal education showed a positive impact on fertilizer-use adoption and maize productivity. This study has significance in the formulation of policy on agricultural extension training and investments to ensure all segments of society are equipped with relevant information for crop yield enhancement and food security.

Keywords: Agricultural Extension; training; Education; Information-inputs; Fertilizer-use, Maize yields

1. INTRODUCTION

Maize (*Zea Mays* L.) is a crop of food security significance in Kenya, consumed as a major staple food by millions of Kenyans. Its production and productivity are hampered by many factors ranging from climatic factors to diseases, poor farming practices associated with low levels of knowledge and external factors including pricing and global fertilizer supplies and demand. The farmers' capacity to utilize superior inputs, due to low levels of knowledge, similarly has a role to play in maize productivity. A model that recognizes this was first developed by Schutz in the 1960s [1], commonly referred to as the high-payoff input model.

The high-payoff input model recognizes three principal inputs as the determinants of crop productivity; research, physical inputs and farmers' capacity to use technology. The model explains that research is an important input in productivity, industrial inputs such as fertilizer and agrochemicals are another and training or capacity-building of the users of research and industrial inputs is the third important high-payoff input [1]. This study investigated the impact of the third high-payoff input; capacity building of smallholder farmers, on the productivity of maize in a rural area with fairly low levels of commercial maize production in the North-rift of Kenya. The capacity of the farmer to take up technology is arguably associated with the level of information inputs possessed by the farmers [2]. Agricultural extension training plays the role of supplying information inputs for agricultural practices. The impact of pieces of training offered through agricultural

extension services and that of formal education as high-payoff inputs were evaluated for their potential power to alter maize productivity as measured by maize grain yields per unit of land.

The following hypotheses guided the study:

- i) **HO-1:** There are no significant differences in fertilizer application rates among small-scale farmers based on their previous exposure to agricultural extension training
- ii) **HO-2:** There are no significant differences in maize yields between farmers who have had contact with agricultural extension training with those who have not.
- iii) **HO-3:** There are no significant differences in fertilizer-use rates among smallholder maize farmers based on their formal education levels, be it basic or higher than basic education.
- iv) **HO-4:** There are no significant differences in maize yields between farmers' groups based on their education levels, whether basic or higher.

2. METHODOLOGY

2.1 Study site

The investigation was executed in Tinderet sub-county in Nandi county of the North-Rift region in Kenya, in a location with a population density of 306 persons per Km² [3]. Nandi county is located between latitude 0° 34'N and longitude 34° 45'E towards the West and 35° 25'E towards the Eastern side [4]. The county borders Kericho, Kisumu, Vihiga, Kakamega and Uasin Gishu counties. The county is a predominantly agrarian county with over 80% of reliance on agriculture for livelihoods. The diverse crops grown include; maize, beans, tea, coffee and sugarcane. In Tinderet sub-county the landholdings are generally small averaging about 2 ha per household. Like in the rest of the county the population is largely agrarian with a population of about 80% dependent on agriculture [3]. Due to the high dependency on agriculture for the provision of livelihoods, the productivity of maize, a staple food in the locality has implications on food security. The area is surrounded by parts of the Mau complex forest towards the East and a sugarcane belt westwards (Figure 1).



Fig. 1: Location of study area

(Source: Primary map from Google Earth, 2022)

2.2 Data collection

The data used in this study is based on 502 households, gathered through a cross-sectional survey. Maize farmers were purposively selected in Tinderet ward. The sample was randomly drawn from a population of about 4,900 households who engaged in maize farming, based on data estimates from KNBS [3]. Four sets of variables are used in this study; agricultural extension training, formal education, fertilizer use and maize yields. The interview schedule used solicited answers as to whether the household head had been trained by agricultural extension agents or not. This was a dichotomous variable (coded 1 – for yes, 0 – otherwise). The level of formal education was captured as ordinal data; coded 1 – for up to primary level and 2 – for secondary level and above. The two variables constituted non-formal and

formal capacity–building in agricultural production for the household-heads. The capacity–building of the farmer was expected to alter the practice of fertilizer-use and to lead to enhanced crop productivity. The third variable on Fertilizer-use was based on quantities applied per acre of maize crop and the fourth, maize yields were measured in 90-kg- bags; a unit commonly used in the area. Data was computed with the aid of SPSS Version 20 to generate descriptive and inferential statistics. The inferential statistics **are** based on the Welch’s t-test and the Mann-Whitney *U* test. The Welch t-test is suitable for analysis on the variation of means between two groups drawn from the same population even when the homogeneity of variance assumption has been violated or the sample sizes are unequal. The Mann-Whitney *U* test is a non-parametric alternative.

2.3 Data Analysis

The Welch’s **t-test** and the Mann-Whitney *U* test were used to test for mean differences between groups. The merits of using a Welch’s t-test is that it does not have the assumption of equal variances and it returns the same results as the standard t-test even when the sample variances are equal [5]. Although it has the assumption of normality, it does not have the assumption of equal variances, a situation which is easily encountered when dealing with **cross-sectional** data. The Welch’s t-test does not use the pooled variance degrees of freedom, instead uses degrees of freedom for each sample. The Welch’s t-test formula is expressed as:

$$\text{Equation} \tag{1}$$

The Mann-Whitney *U* test was also used as a non-parametric alternative, based on the formulae:

$$\begin{aligned} U_1 &= n_1n_2 + \frac{n_1(n_1+1)}{2} - \Sigma R_1 \\ U_2 &= n_1n_2 + \frac{n_2(n_2+1)}{2} - \Sigma R_2 \\ U &= \text{Min} (U_1, U_2) \end{aligned} \tag{2}$$

Mann-Whitney *U* is the minimum of the *U* values for samples 1 and 2.

U_1 = Mann–Whitney *U* statistic for sample 1

U_2 = Mann–Whitney *U* for sample 2

n_1 = Sample size for group 1

n_2 = Sample size for group 2

ΣR_1 and ΣR_2 = Sum of the ranks for sample 1 and 2 respectively.

The Mann–Whitney *U* was computed with the aid of SPSS Version 20.

3. RESULTS AND DISCUSSION

3.1 Participants’ Socio-demographics

The farmers who participated in the study were aged between 21 and 89 years with 27.9% being youth aged below 35 years, 26.1% **aged** 36-45 years, 21.3% aged 46-55 years and 24.7% over 55 years. The mean age was 46.3 years. About 65.2% of the participants had formal education up to primary and 34.8% had secondary and tertiary level education. There were 63.5% males interviewed and 36.5% females. The mean household size was 5.9 **and the median and mode were 6.**

3.2 Influence of Extension Training on Fertilizer-use and its impact on maize yields

Agricultural **extension** training is viewed as a high-payoff input into the practice of farming. It supplies the requisite information-inputs for productivity-enhancement [2]. It is noted, however, that not all technologies are adopted. The adoption of technologies is influenced by many factors, including socio-demographics of the farmers [6]. This study tests the null hypothesis;

HO-1: There is no significant difference on fertilizer application rates among small-scale farmers based on their previous exposure to agricultural extension training.

About 42.8% of the respondents reported that they had not received any training from agricultural extension agents on crop production, 57.2% reported that they had been trained. A test for differences in fertilizer use showed a significant difference between the trained groups with *not trained* group based on Welch’s t-test, $t(482.785) = -9.228, P = .000$. The group ‘not trained’ had a mean fertilizer-use rate of 35.16 ± 28.438 , while the group that had been trained had a mean of 59.95 ± 31.477 (Table 1). The mean differences were highly significant ($P < .001$). Those who received Extension training and had up to primary level of education recorded a mean in fertilizer-use rate of 55kg/acre, while those who received Extension training and had secondary school education and above posted a mean fertilizer-use rate of 65kg/acre (Figure 3). This is an interesting finding, suggesting that no matter the education levels of the farmer, Extension training has an

impact on fertilizer-use adoption. It underscores the importance of relevant, targeted information in maize productivity enhancement.

A non-parametric test based on the Mann-Whitney U test showed a significant difference between the *trained* and the *not trained* groups, $U(N_1 = 215, N_2 = 287) = 17457, Z = -8.510, P = .000$, suggesting that extension training had a significant influence on fertilizer-use among the smallholder farmers. The strength of the effects of training was assessed using Eta-squared (η^2) coefficient as worked out from the Z value, thus: $\eta^2 = \frac{Z^2}{n-1} = \frac{(8.510)^2}{502-1} = 0.1445$. The findings suggest that about 14.5% of the variation in fertilizer-use rates could be attributed to the reported training exposure of the farmers. According to Cohen [7], an Eta-squared value of 0.14 or higher can be regarded as a large effect. The large η^2 value implies that Agricultural Extension training has a large impact on fertilizer-use technology. It is plausible that Extension training supplies the relevant information inputs for the adoption of technology [2]. This observation has implications for maize yields.

The response of maize to fertilizer application showed a quadratic response pattern as illustrated in Figure 2. A large proportion of the variation in maize yields could be explained by fertilizer use as estimated by a quadratic regression. The curvilinear relationship indicates that there is a lower impact of fertilizer use at low doses and a sharper increase in yields at higher doses as demonstrated by the findings in Figure 3. This implies that farmers' training on the appropriate application of inorganic fertilizer can result in a rapid increase in maize yields. The quadratic regression model has R^2 adjusted for the entire population of .522. This indicates that about 52.2% of maize yields can be explained by fertilizer application rates in the population from which the sample was drawn. This has implications for policies on agricultural extension training and public investments that encourages the appropriate use of fertilizers.

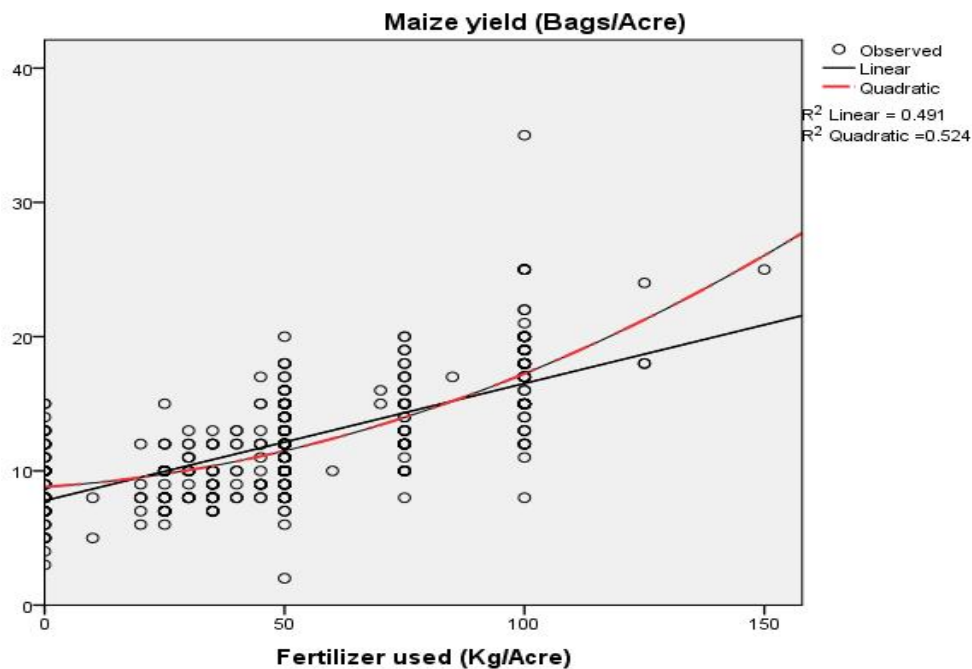


Fig. 2: Observed Relationship between Fertilizer application and maize yields

3.3 Influence of Extension Training on Maize yields

HO-2: There are no significant differences in maize yields between farmers who have had contact with agricultural extension training with those who have not.

This hypothesis was vigorously tested by the use of Welch's t-test at a 95% confidence interval. Further analysis of the effect size is based on Eta squared (η^2), as estimated from the formula:

$$\eta^2 = \frac{t^2}{t^2 + (n_1 + n_2 - 2)} \quad \text{Equation (3)}$$

Where t is the observed t-test value, n_1 and n_2 are the sample sizes for groups 1 and 2 respectively

The *Trained* group posted a mean yield of 13.10 ± 4.425 bags/acre of maize grain as compared to the *not trained* group mean of 10.73 ± 3.040 as captured in Table 1. Based on Welch's t-test the differences were highly significant, $t(496.513) = -7.095, P = .000$. Analysis based on the Mann-Whitney U test similarly showed a highly significant difference, $U(N_1 = 215, N_2 = 287) = 20952.5, Z = -6.195, P = .000$ (Table 2). The effect size as measured by Eta-squared was of medium strength, $\eta^2 = 0.76$. About 7.66% of the variation in maize yields could be attributed to the training. According to Cohen [7], this is a medium-sized effect. The differences in mean maize yields between the "trained" and "not trained" groups is as

illustrated in Figure 4. The highest mean yields were exhibited by those who had been trained and had prior formal education of secondary level and above.

Table 1: Fertilizer-use and maize yields per acre based on Extension training status

	Trained?	N	Mean	Std. Deviation
Fertilizer used (Kg/Acre)	Not Trained	215	35.16	28.438
	Trained	287	59.95	31.477
Maize yield (Bags/Acre)	Not Trained	215	10.73	3.040
	Trained	287	13.10	4.425
Manure use	Not Trained	215	.32	.468
	Trained	287	.53	.500

The mean age for the respondents who reported that they 'had not been trained' by agricultural extension agents was 49 ± 15.7 , while that for the group that had been 'trained' was 44.0 ± 13.1 . The differences in mean age were highly significant, $t(410.0) = 3.962$, $P = .000$. This observation is consistent with the long-held assertion by Rogers [6] that information-seekers in every social system tend to be younger. Given that information from agricultural extension training is open to all members of society, this finding suggests that the more elderly farmers may be harder to reach through extension as compared to the younger ones.

Agricultural extension training, a non-formal form of education without a rigid curriculum and a formal environment, is the primary focus of any agricultural extension system. Such a system provides relevant technical and scientific information inputs for the better use of farm resources. The better use of farm resources in turn provides for the livelihoods of farm households, including ensuring food security. It enhances the food security situation, the access to adequate food that provides for dietary needs and food preferences all the time [8]. The current finding suggests that the farmers' training sessions provided the relevant information inputs for the better yields obtained *with training* as compared to *without*. This observation is in tandem with the arguments by [9] that soil fertility related technologies are 'knowledge intensive'. The current findings indicate that the information delivered through training to boost farmers' knowledge resulted in better crop yields.

Table 2: Influence of Extension training on fertilizer-use and maize yields

Variable	Fertilizer-use			Maize yields		
	df	Statistic	Sig.	df	Statistic	Sig.
T-test	482.785	- 9.228	.000	496.513	- 7.095	.000
Mann-Whitney U	N1 = 215 N2 = 287	17457	.000	N1 = 215 N2 = 287	20952.5	.000
Z value		- 8.510	.000		- 6.195	.000
Eta-Squared		.1445			.0766	

In order to adjust for the potential confounding effect of formal education on the outcome, an analysis of variance was run while adjusting for the effects of formal education expressed as a dummy variable (for basic and higher education, 0 and 1 respectively). The assumption of linearity was tested by use of a scatter plot. This test was intended to answer the question; did past formal education training have any significant influence on maize yields?

There was a statistically significant difference between the adjusted means for "not trained" and "trained" groups ($P < .05$). This suggests that formal education levels did not show a significant compounding effect on maize yields. The observation means that the agricultural-extension training positively influenced maize yields when other factors are held constant. Similar findings were reported from Ghana where farm productivity was enhanced by agricultural extension packages designed for farmer training [10]. According to the authors, the income from maize crops increased by about 20% following the exposure of the farmers to an extension program that offered training on maize production. Participation in the program increased farm productivity by about 11%. In recognition of the impact of the Extension training, the authors recommended more human, financial and logistical resources for agricultural extension delivery to boost productivity and household incomes. The current finding similarly suggests a need to support agricultural-extension services to deliver information inputs among small-scale farmers. A recent study by [11] reported a decline in funding for agricultural-extension services following the transfer of the function from national to county governments in 2010. The significant role played by agricultural-extension training among small-scale farmers suggests a need for adequate facilitation of the extension service in delivery of information inputs for smallholder farmers.

The influence of extension-training on crop productivity was reported in a similar study among rice farmers in Uganda where exposure to extension training resulted in increased rice yields [12]. A dissimilar case is, however, reported in the same country where there was an insignificant impact of extension on agricultural productivity, with the researchers partly attributing it to insufficient access to the extension services [13], suggesting that the poor access to extension services may have been the reason for the insignificant impact. In Kakamega, Kenya a study reported increased productivity based on access to soil-related agricultural information from Extension services [14]). Tambi [15] reported that household agricultural training strongly affected agricultural production. The author argued that awareness training tended to create an urge for even higher training.

3.4 Influence of Formal Education on Fertilizer-use Rates

The formal education system in Kenya is structured into the primary level, secondary and tertiary, which include colleges and University education, each with a specified curriculum and time frame. In this study, basic education refers to the primary level, whereas secondary and above are regarded as higher than basic. Specialized courses are covered at the tertiary level. This study tested the null hypothesis:

HO-3: There is no significant difference in fertilizer-use rates among smallholder maize farmers based on their formal education levels, be it basic or higher than basic education.

The hypothesis was tested by the Welch t-test at a 95% confidence interval. The mean yields on fertilizer application and their standard deviations are indicated in Table 2. The mean difference between the groups based on their formal education levels was statistically significant, Welch $t(332.28) = -5.699$, $P = .000$, thus the null hypothesis is rejected. The Eta squared statistic as worked out from the t value was .089, indicating that 8.9% of the variation in fertilizer use rates could be attributed to formal education levels. The mean fertilizer application rate for the primary level category was 43.32 ± 30.659 , while that for the secondary level and above was 60.57 ± 33.183 as captured in Table 2. This is an interesting finding that concurs with a study in Ghana which reported that farmers who had attained secondary and tertiary education tended to adopt the use of inorganic fertilizers [16]. The finding suggests that awareness alone is not sufficient to persuade smallholder farmers to invest in fertilizers; it probably requires a deeper understanding of the value of fertilizers for one to do so. Such deep understanding may be accessed through formal education training.

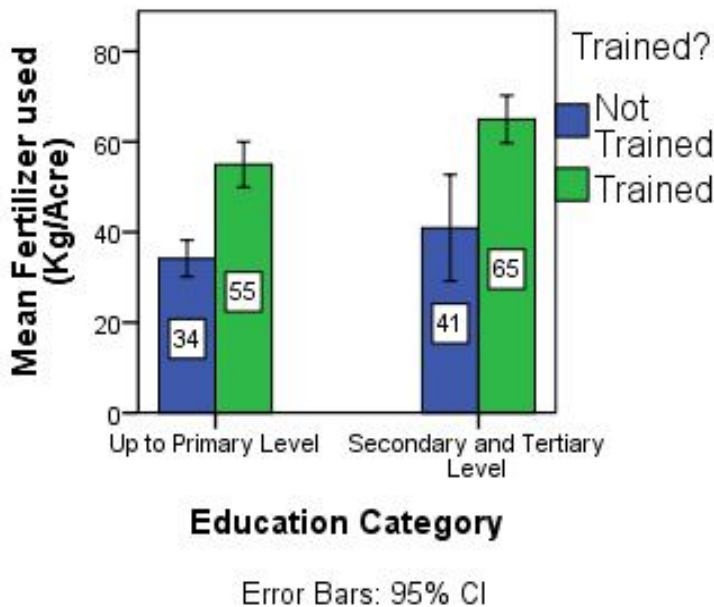


Fig. 3: Influence of Extension training and Education on Fertilizer use

3.5 Influence of Formal Education on Maize yields

HO-4: There are no significant differences in maize yields between farmers' groups based on their education levels, whether basic or higher.

The null hypothesis that there is no significant difference in maize yields between groups of farmers based on their categories on formal education levels of basic (up to primary level) and higher levels (secondary and tertiary) was tested at a 95% confidence interval using the Welch t-test. The mean maize yields for the school level category 'up to primary' was 11.34 ± 3.56 and the category of secondary and above had a mean of 13.49 ± 4.54 (Table 1). The mean differences between the two categories were significant, Welch $t(290.29) = -5.438$, $P = .000$. The test rejected the null hypothesis

and concluded that the levels of yields recorded for the basic education group were significantly lower than for the higher formal education group.

The effect size was estimated using Eta squared (η^2), based on the formula for converting observed t-test values into Eta squared coefficients (Equation 3). This was worked out thus; $(5.438)^2 / [(5.438)^2 + (502-2)] = .06$. This suggests that formal education has a **medium-strength** effect on maize yields. Based on the conventions for interpreting Eta-squared where .01 is regarded as a small effect, .06 as medium and .14 and above as a large effect [17], the observed value of .06 is a medium-strength effect. This observation indicates that about 6% of the variation in maize yields is attributed to changes in formal education levels from basic to secondary level and above.

Table 3: Fertilizer-use and maize yields per acre based on formal education levels

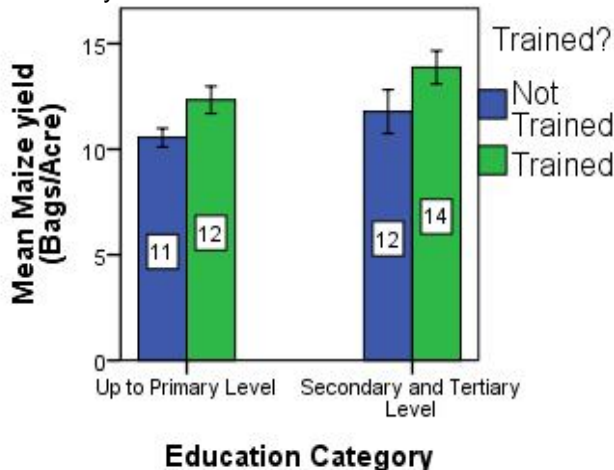
Variable	Education Category	N	Mean	Std. Dev.
Maize yield (Bags/Acre)	Up to Primary	327	11.34	3.562
	Secondary & above	175	13.49	4.548
	Up to Primary	327	43.32	30.659
Fertilizer used (kg/acre)	Secondary & above	175	60.57	33.183

A test for mean differences based on Mann-Whitney *U* test returned similar results, a highly significant difference between the two categories, $U (n_1 = 327, n_2 = 175) = 20,506, Z = -5.267, P = .000$. The Eta squared (η^2) value based on the *Z* score was worked out as; $\eta^2 = \frac{Z^2}{N-1} = (5.267)^2 / 501 = .06$, thus giving the same result as the conversion of the t-value. The non-parametric approach thus yielded a similar effect size from formal education on the maize yields as depicted in Table 4.

Table 4: Influence of formal education on fertilizer-use and maize yields

Variable	Fertilizer-use			Maize yields		
	df	Statistic	Sig.	df	Statistic	Sig.
T-test	332.28	- 5.699	.000	290.29	- 5.438	.000
Mann-Whitney <i>U</i>	$N_1 = 327$ $N_2 = 175$	20083.5	.000	$N_1 = 327$ $N_2 = 175$	20506	.000
Z value		-5.626	.000		-5.267	.000
Eta-Squared		.063			.064	

The influence of formal education on overall maize yields though appearing small, has food security implications illustrated in Figure 4. Those with education levels up to primary level had a mean yield of 11.34 ± 3.562 and that of secondary /tertiary education had a mean of 13.49 ± 4.548 . The mean difference of about 2 bags (2 x 90-kg bags) is an amount that is sufficient to provide for 2 adults their maize requirements for a year at consumptions per capita of about 88-103kgs [18]. Since the compounding effect of education on Extension training was not statistically significant, it suggests that both Extension training and formal education have independent contributions to make in regard to the productivity of maize.



Error Bars: 95% CI

Fig. 4: Influence of Extension training and Education on maize yields

4. CONCLUSION

Agricultural extension training, a form of non-formal education, influenced fertilizer-use adoption and maize productivity. There is a positive impact of agricultural extension training on maize productivity and its contribution to food security among rural households. The natural control group in the study who had not received any crop production training constituted about 42.8%. This finding has implications for its contribution to policy formulation in agricultural extension training for smallholder farmers so that all segments of society receive relevant information for maize-yield enhancement and food security. There was a positive impact of formal education on fertilizer use and maize productivity. Non-formal training needs to be up-scaled to compensate for low levels of formal education among smallholder farmers.

CONSENT

Individual consent was sought from the respondents during data collection.

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