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The relationship between training farmers in agronomic practices and diet diversification: a case study from an intervention under the Scaling Up Nutrition programme in Zambia

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Abstract

Background: Agricultural production systems are a sustainable way of providing nutritious and diversified foods especially among rural households in developing countries. Capacity building of farmers and extension workers through training on agricultural and nutrition-related topics is one of the ways to improvements in agricultural productivity. However, a few studies have shown there is a link between training in agronomic practices and crop diversification and the effect this relationship has on diet diversity. Therefore, this study was carried out in Zambia in four districts and within those districts intervention ($N = 348$) areas were compared to nonintervention sites ($N = 194$) using an individual household questionnaire to investigate the effectiveness of training sessions that were conducted under the Most 1000 Critical Days program, the scaling up of nutrition on farm production diversity and diet diversity at household level.

Results: The results show that there were significant differences in the proportion of farmer households that grew different types of crops ($P < 0.001$). The incorporation of legumes such as soybean, groundnut and beans into crop production may enrich household diets with essential macro- and micronutrients. Results further indicate that training on agronomic practices was associated with increased productivity and diversification of production and dietary intake.

Conclusion: This study has shown that targeted interventions aimed at increasing food crop production and dietary diversity have the potential to improve food production and dietary diversity. These findings reinforce the premise that crop diversification has a positive correlation with diet quality. Similarly, training farmers on food production, processing and dietary diversification is critical not only in improving agronomic practices but also the diet of farmers.

Keywords: Farm production diversity, Agriculture production systems, Diet diversity, Agronomy training

Background

Agriculture has a special role in mitigating child and maternal undernutrition in several ways [1] that include making diversified foods available and accessible [2]. Agricultural practices tend to determine the level of food production diversity [3]. Several studies have shown linkages between food production, income and diet diversity. Having more income may lead to increased access to diversified diets, and a varied diet is associated with nutrient adequacy [4]. In terms of food accessibility, a growth in agricultural GDP has been associated with a

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reduction in undernutrition, while in some cases it has led to an increase in being overweight and obesity. However, agriculture growth reaches the poor more effectively [5, 6]. Diversified diets are more likely to provide required nutrients in the right quantities for the population, especially the nutritionally vulnerable groups that include women, children and the elderly [5]. Training of farmers and extension workers on agricultural and nutrition-related topics leads to an improvement in agronomic practices among farmers [7]. Farmers that are properly trained and supported in agronomic practices tend to produce a variety of crops and realize high yields. Because of increased food diversity and availability, these farmers tend to be food secure and can diversify their diets.

In Zambia, about 70% of the population is involved in agriculture including urban agriculture [8]. The level of food insecurity is, however, high and evident in the form of malnutrition, The Food and Agriculture Organization (FAO), the International Fund for Agriculture Development (IFAD) and the World Food Programme (WFP) [9] estimate that 48.3% of the population is malnourished, especially children less than 5 years of age, and that crop and diet diversity among farmers are poor [9]. A recent survey evaluating the nutrition and food diversity among smallholder farmers found high levels of food insecurity and low crop and diet diversity among farmers 3 months after harvest [10]. The International Institute for Tropical Agriculture (IITA) implemented a project to evaluate the role of improved farming practices including increased production of highly nutritious crops on dietary diversity and nutrition of farmers in four districts of Zambia. The intervention focused on the introduction of improved, nutrient-dense crop varieties, crop management practices and dietary diversification among the farmers for the benefit of 12,000 children under 2 years of age and 3000 pregnant or lactating women. Provision of 3 kg each of three types of legume, three spoonfuls of three types of vegetable seeds, and Moringa, papaya and guava seedlings was made as part of the intervention. The intervention involved meetings on the proposed activities with district and community-based stakeholders and facilitators. The District Nutrition Coordinating Committees were particularly important for these meetings which solicited their support for the implementation of the intervention actions. In addition to meetings, training, nutrition education and behavior change communication by community facilitators and extension workers targeting 5000 farmers and 100 seed producers were the main approaches of reinforcing the intervention actions. The objective of this paper is to share information on the analysis of data obtained as part of an end-of-project evaluation for this intervention. The analysis in this paper only focuses on the association between farmer training and knowledge transfer on agronomic practices and crop and dietary diversity.

Methods

A mixed-methods experimental design was utilized in the evaluation of the intervention effects. As no baseline was undertaken at the commencement of the intervention, a quasi-experimental approach was adopted at the evaluation stage through the selection of a subsample in a nonintervention area to help with the quantification of intervention effects [11]. The interventions were implemented for 2 years (2014–2016) in four agricultural camps: Mansa in Luapula Province, Kasama in Northern Province, and Lundazi and Chipata in Eastern Province.

Sample size

The intervention was designed to reach 12,000 children under 2 years old and 3000 pregnant or lactating mothers. The evaluation sample (n) was estimated using the World Health Organization ENA SMART software which uses the formula below:

$$n = \left[z^2 \times \frac{pxq}{d^2}\right] \times \text{DEFF}$$

In the calculation of the sample size, the prevalence rate (p) of 15% for underweight was used [12]. With the assumption of heterogeneity among populations in the districts, a design effect (DEFF) of 2 to account for these variations was used. The relative desired precision (d) of 10 was used since the prevalence of being underweight is high. According to SMART, with high prevalence, precision does not need to be high for appropriate decision making on whether interventions should be instituted. SMART further postulates that at a prevalence of over 10%, services will be overwhelmed and urgent and substantial interventions would be needed. Therefore, a confidence interval (z) of $\pm$ 5.0% is acceptable [13]. Other parameters used were the population of children 0–59 months estimated at 20% of the total population, the average household size estimated at 5 [14] and the percentage of non-response households estimated at 6%. A 6% non-response was used because a low response rate was expected to be minimal since the study was carried out among intervention beneficiaries.

Sample allocation

To achieve equal precision in the estimates in the four districts, the equal sample allocation method (ESAM), based on the established minimum samples for a cluster, was adopted [15]. Since the focus was to have good separate estimates at agriculture camp level, ESAM was the best allocation method available.

Statistical analysis

Data were subjected to statistical analysis to generate descriptive statistics such as frequencies and to establish relationships between variables. The Chi-square test was used to test differences in prevalence of categorical variables, while the Student *t test* was used to determine differences between means of continuous variables. Results are shown in the tables.

Results

Description of study participants

Most households were headed by males (52.9%), while 47.1% were headed by women. Table 1 presents information on socio-demographic characteristics of the study participants.

Results in Table 1 show that most household heads were of low socioeconomic status and had little formal education Some household heads were divorced or widowed (26.6% intervention and 45.0% nonintervention). This might have led to the majority (81.3%) of household heads working in informal employment and 18.7% not employed.

Table 2 indicates the distribution of participant smallholder farmers by district and age group.

The results in Table 2 show significant differences in the distribution of the participants in the 15–49 age category. Among women, this age category is critical because it is considered the reproductive age. A study of factors affecting adoption of agricultural innovations in Erzurum Province, Turkey [16], found that the farmers' age was statistically significant ($P = 0.01$) regarding the adoption of innovations such as artificial insemination and that younger farmers tended to adopt the technology. These findings have been corroborated by the results of a study conducted by Mwangi and Kariuki [17] in a meta-analysis of *Factors determining adoption of new agricultural technology by smallholder farmers in developing countries*. In their analysis, age of farmer was found to have a negative relationship with adoption of technology. This showed that as farmers grow older, risk aversion increases and there is also decreasing interest in long-term investment in the farm. On the other hand, younger farmers have been found to be less risk-averse and are more willing to try new technologies. This implies that targeting younger farmers with interventions would lead to increased adoption of technologies. This study has shown no differences in the distribution of participants in the age categories of 50–59 and 60+ years.

Table 1 Socio-demographic characteristics of study participants

Characteristics	Intervention (*N* = 348)		Nonintervention (*N* = 194)	
	n	Percent	*n*	Percent
Sex				
Female	265	76.1	160	82.5
Male	83	23.9	34	17.5
Marital status of household head				
Never married	5	3.7	0	0
Married	94	69.6	39	54.9
Divorced or separated	16	11.8	15	21.1
Widowed	20	14.8	17	23.9
Education level of household head				
None	10	5.0	3	2.5
Grade 1–7	131	65.5	91	74.6
Grade 8–9	35	17.5	23	18.9
Grade 10–12	24	12.0	5	4.1

Production

During the 2014/15 farming season before the intervention, most farmers cultivated less than 0.5 hectares in both intervention and nonintervention groups (Table 3). Small land holding sizes of less than one hectare per household are associated with an increased risk of food insecurity. This is because such land constraints lead to low crop yields, lack of diversity of crops grown, and difficulties in mechanizing production. The dominance of maize production in both intervention and nonintervention groups is evident as shown in Table 4. During the 2015/16 farming season, there was an increase in the number of farmers growing other types of crops. This increase may be attributed to project interventions.

The results in Table 3 show acute land shortages in the study area. There are significant differences in land sizes under cultivation ($P = 0.03$). Most households in the nonintervention group cultivated less than half a hectare of land. These findings imply that households should be provided with innovations that increase crop production and maximize the use of such land. Table 4 presents information on the proportion of households growing different types of crops in the intervention and nonintervention groups.

The results in Table 4 further show that there were significant differences in the proportion of farmer households that grew different types of crops ($P < 0.001$). Incorporation of legumes such as soybean, groundnut and beans into crop production may enrich household diets with micronutrients. Legumes also increase soil fertility which results in increased crop production. Inclusion of orange-fleshed sweet potato, orange maize and green vegetables in household food production may also increase intake of vitamin A among household members.

Farmer training

Farmers were trained in different agricultural practices as outlined in Table 5. The training sessions were conducted

Table 2 Distribution of study participants by age group

Age group	Chipata				Kasama				Lundazi				Mansa				P value
	Intervention		Nonintervention		Intervention		Nonintervention		Intervention		Nonintervention		Intervention		Nonintervention		
	n	Percent	n	Percent	n	Percent	n	Percent	n	Percent	n	Percent	n	Percent	n	Percent	
15–49	79	90.8	35	71.4	82	88.2	84	90.3	62	82.7	47	83.9	87	93.5	32	76.2	0.023
50–59	6	6.9	10	20.4	10	10.8	10	10.8	10	13.3	5	8.9	3	3.2	5	11.9	0.346
60+	2	2.3	4	8.2	1	1.1	1	10.6	3	4.0	4	7.1	3	3.2	5	11.9	0.778
All	87		49		93		93		75		56		93		42		

Intervention (n) = 348, nonintervention (n) = 194

Table 3 Distribution of arable land cultivated during the (2014/15) farming season

Area under cultivation	Intervention		Nonintervention	
	n	Percent	n	Percent
< 0.5 ha	263	75.6	176	90.7
0.5–1 ha	65	18.7	9	4.6
1–2 ha	9	2.6	4	2.1
> 2 ha	11	3.2	5	2.6
Total	348	100	194	100

$X^2 = 59.6, P = 0.03$

Table 4 Proportion of farmer households growing cereals, pulses, legume and tuber in the 2014/15 farming season

Crops	Intervention (n = 348)		Nonintervention (n = 194)	
	n	Percent	n	Percent
White maize	206	59.2	188	96.9
Orange maize	39	11.2	1	0.5
Beans	9	2.6	0	0
Soybeans	18	5.3	0	0
Cowpea	10	2.9	0	0
Cassava	7	2.0	1	0.5
Orange-fleshed sweet potato	4	1.1	0	0
Moringa	5	1.4	0	0
Groundnuts	39	11.2	4	2.0
Green vegetables	7	2.0	0	0

$\chi^2 = 90.457, P < 0.001$

by lead implementers and camp agriculture officers. In Zambia's agricultural extension system, camp refers to an administrative base for the Department of Agriculture extension staff who are responsible for all the farmers in their respective agriculture extension areas. Usually there is one staff member per camp who serves as an Agriculture Assistant. The Camp Agriculture Officer provides advice to farmers on agricultural issues [18]. They

Table 5 Distribution of respondents by type of training session attended

Training topic	Intervention (n = 348)		Nonintervention (n = 194)		P value
	n	Percent	n	Percent	
Sustainable farming methods	336	96.6	120	88.2	0.001
Improved agronomic practices	333	95.7	118	60.8	0.001
Improved varieties and nutrient-rich varieties	332	95.4	112	57.7	0.001
Vitamin A-rich crops	332	95.4	102	52.6	< 0.001
Food storage	333	95.7	110	56.7	< 0.001
Food preservation, processing and utilization	333	95.7	107	55.2	< 0.001
Various methods of cooking food	331	95.1	105	54.1	< 0.001
Infant and young child feeding	333	95.7	105	54.1	< 0.001
Diet diversification	330	94.8	106	54.6	< 0.001

then cascade the training to the rest of the beneficiaries with over 95% of sampled beneficiaries confirming having received training in agronomic practices and nutrition. Table 5 shows the distribution of farmers that were trained on different topics.

The results in Table 5 show significant differences in the proportion of respondents that were trained on various topics. However, over half of all the respondents in the nonintervention group were also trained on the same topics as the intervention group. These results therefore show that despite the interventions introduced by IITA, there were also other extension service agents providing similar services. Interpretation of the findings should therefore be done with caution as not all the achievements can be attributed to the project interventions.

Effect of training on uptake of recommended practices

Table 6 presents information on the proportion of respondents who demonstrated knowledge and ability

Table 6 Proportion of trained participants who demonstrated knowledge and ability to practice recommended agriculture and nutrition practices

Training topic	Change in knowledge after training						Able to practice the knowledge	
	Intervention			Nonintervention			Intervention	Nonintervention
	Same	Improved	Can't tell	Same	Improved	Can't tell		
Sustainable farming methods	4.7	94.1	1.2	7.1	77.0	15.9	95.3	80.6
Improved agronomic practices	4.4	94.4	1.2	7.1	75.4	17.5	94.4	80.0
Improved varieties and nutrient-rich varieties	5.3	93.2	1.5	11.1	67.5	21.4	93.2	57.8
Vitamin A-rich crops	5	93.2	1.8	11.1	65.9	23.0	94.1	56.7
Food storage	5.3	93.5	1.2	7.9	66.7	25.4	95.3	66.4
Food preservation, processing and utilization	4.7	94.1	1.2	12.7	63.5	23.8	95.9	60.7
Various methods of cooking food	5.0	93.8	1.2	12.7	61.9	0.8	95.9	55.6
Infant and young child feeding	5.0	93.8	1.2	15.1	61.9	23.0	95.9	56.3
Diet diversification	5.9	93.2	0.9	14.3	61.9	23.8	95.3	58.5

to practice what was learnt in the training sessions and during follow-up supportive sessions. Most respondents who were trained on various recommended practices in agriculture, food and nutrition demonstrated knowledge and skills in carrying out the recommended practices. Over 93% of those who were trained reported that they practiced what they had learned. The common practices included following sustainable farming methods, improved agronomic practices such as use of improved varieties and nutrient-rich varieties, food storage, food preservation, processing and utilization and dietary diversification. Training on agronomic practices was associated with increased productivity and diversification of production and dietary intake [MD = − 0.959, SE = 0.149, CI (− 1.251, − 0.666)] (Tables 7 and 8).

Table 7 Proportion of farmer households growing different crops in two farming seasons

Crops grown 2015/2016	Intervention (*n* = 348)		Nonintervention (*n* = 194)		*P*
	n	Percent	*n*	Percent	
White maize	337	62.2	194	35.8	0.28
Orange maize	203	61.3	32	9.7	0.08
Beans	3	0.6	0	0	
Soybean	184	60.9	54	14.8	0.01
Cowpea	141	42.3	53	15.9	< 0.01
Cassava	137	37.8	79	21.8	< 0.01
Orange-fleshed sweet potato	113	39.0	41	14.1	< 0.01
Pawpaw	76	32.3	24	10.2	0.001
Green vegetables	103	33.0	77	24.7	< 0.01
Moringa	63	32.6	11	5.7	0.01
Groundnut	39	7.2	4	0.7	< 0.01

Table 8 Percentage distribution of households by HDDS

Dietary quality	Intervention [*n* = 348 (%)]	Nonintervention [*n* = 194 (%)]	*P*
Diversified	201 (57.8)	66 (34.0)	0.001
No diversity	147 (42.2)	128 (66.0)	

The results in Table 6 show that most participants in the intervention group indicated that their knowledge had changed after undergoing the training. There were significant differences ($P < 0.01$) in the proportion of respondents who indicated change of knowledge after training. Most respondents also indicated that they could practice the knowledge gained during the training. Table 7 presents information on the proportion of farmer households that grew different crops during the 2014/2015 and 2015/2016 growing seasons.

Dietary diversity

Dietary diversity refers to the total number of food groups that one consumes over a reference period of 24 h [18]. The average number of food groups that a household had consumed in the previous 24 h was estimated at 5.95 ± 1.65 in the intervention group ($n = 348$) and 4.99 ± 1.15 in the nonintervention group ($n = 194$). There were significant differences in dietary diversity between the two groups ($P = 0.001$). The dietary diversity scores (DDS) used to determine dietary quality were grouped into three categories: poor quality (< 4 food items), moderate quality (4–6 food items) and good quality (> 6 food items) [19]. Table 8 shows the distribution of households by the DDS. Results indicate that the more households in intervention households had diversified diets than nonintervention households.

Most commonly consumed food Item

During the evaluation, data were collected on the various food groups that were eaten during the 24 h prior to the evaluation in line with established procedures [20]. Table 9 shows that cereals were the most commonly consumed food group in both intervention and nonintervention groups.

Dark green leaves and oils/fats were also consumed by most households in both groups. The least consumed food groups by households in both intervention and nonintervention groups were organ meats. Even so, in the intervention group, a significantly higher number of households consumed foods from different food groups than in the nonintervention group ($P < 0.05$).

Conclusion

In this study, we examine the effects of training farmers in agronomic practices on crop and diet diversification in Zambia's farming community. Our results show a strong and positive association between crop diversification and nutrition measures in the form of diet diversity.

The study concludes that training farmers on different agronomic topics can influence crop diversity and productivity. These findings reinforce the premise that interventions that aim at improving crop diversification have a positive correlation with diet quality. Similarly, training farmers on food production, processing and dietary diversification is critical not only in improving the agronomic practices but also the diet of farmers.

Furthermore, the area under cultivation could increase in two farming seasons as the crop diversity and diet diversity also increased. An evaluation conducted in Bangladesh [21] using a contribution analysis-based evaluation approach showed that training farmers in agriculture and nutrition resulted in increased per capita production and subsequently, the diversity of production and frequency of harvesting tend to increase. Another evaluation of an intervention supplying women with improved varieties for small-scale production in Saturia District of Bangladesh found sustained improvements in the nutritional status of women and children for early adopters [22]. In our analysis, we found that over a 2-year period, training of farmers on different topics improved farming approaches among farmers. We also found an improvement in crop diversity and area of land (ha) under cultivation. There was also an improvement on household dietary diversity scores. This study did not determine the effects of the interventions on anthropometry and micronutrient status of the farmers. However, increased consumption of dark green vegetables, pulses and fats and oils could increase micronutrient intake, so improving micronutrient nutrition among farmers' households.

We recommend with clear evidence that programs that promote crop diversification should be scaled out on a large scale in collaboration with different implementing partners and should be supported by donors to reduce the risks that result from putting more emphasis on one crop especially in Southern Africa where emphasis is on maize rather than other crops. Crop diversification equips smallholder farmers with the necessary safety-net measures in times of crop failure, especially now most farmers are affected by climate change. Crop diversification offers farmers alternative sources of income and improves food and nutrition security as evidenced in this study through improved diet diversity scores. The scaling out of such programs is best done in partnership with different agencies working in the area of food and nutrition security. This helps in scaling up of promoted technologies.

Table 9 Percent distribution of households consuming foods from various food groups

Food group	Intervention ($n = 348$)		Nonintervention ($n = 194$)		*P*
	n	Percent	*n*	Percent	
Cereal	343	98.6	184	94.8	0.01
White roots and tubers	163	46.8	79	40.7	0.10
Dark green leafy vegetables	287	82.5	147	75.8	0.04
Vitamin A-rich fruits	51	14.7	5	2.6	< 0.01
Flesh meats	65	18.7	26	13.4	0.07
Eggs	47	13.5	13	6.7	0.01
Fish and sea foods	157	45.1	83	42.8	0.33
Pulses	129	37.1	42	21.6	< 0.01
Milk and milk products	61	17.5	20	10.3	0.02
Oil and fats	307	88.2	144	74.2	< 0.01
Sweets	225	64.7	97	50	< 0.01
Spices, condiments, beverages	237	68.1	129	66.5	0.38

Authors' contributions

TMG involved in designing and carrying out the experiment and developing the manuscript; EOA involved in designing and carrying out the experiment and contributing to development of the manuscript; MM contributed to the development of the manuscript; BMD supervised the experiment; NG statistical analysis of data and contributed to the development of the manuscript. All authors read and approved the final manuscript.

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