The European Journal of Development Research
https://doi.org/10.1057/s41287-021-00481-2

ORIGINAL ARTICLE

Production of Indigenous Food Crops: Implications for Children's Nutritional Status of Farm Households in Northern Ghana

Alhassan Andani[1] · **John Baptist D. Jatoe**[2] · **Ramatu M. Al‑Hassan**[2]

Accepted: 21 October 2021

Abstract
This paper examines the effect of indigenous food crops on the nutrition security outcomes of children in farm households. Using a standard treatment effect model, data on children under 5 years of age from 250 farm households in selected rural districts of northern Ghana were analysed. A multistage sampling procedure was used. Descriptive statistics show high rates of child wasting (16.7%), stunting (29.8%) and underweight (25.2%), but suggest better nutritional status for children in indigenous food crops producer households than those in non-producer households. Children in producer households have higher height-for-age; weight-for-height and weight-for-age *z*-scores than children in non-producer households. The findings suggest that, children in non-producer households are more at risk of being stunted, wasted and underweight than those in producer households. Exploring the empirical link between the production of indigenous food crops and the nutrition status of children in northern Ghana extends the literature on nutrition and crop production.

Keywords Northern Ghana · Nutrition security outcomes · Child anthropometric measures · Indigenous food crops · Treatment effect model · Farm households

Résumé
Cet article étudie l'effet des cultures vivrières indigènes sur la sécurité nutritionnelle des enfants issus des ménages agricoles. À l'aide d'un modèle standard d'effet de traitement, nous avons analysé les données concenant les enfants de moins de cinq ans issus de 250 ménages agricoles sélectionnés dans des districts ruraux au nord du Ghana. Une procédure d'échantillonnage à plusieurs degrés a été utilisée. Les statistiques descriptives montrent chez les enfants des taux élevés d'émaciation (16,7

✉ Alhassan Andani
zangbalungdow@gmail.com; alhassan.andani@uds.edu.gh

1 Department of Food Security and Climate Change, University for Development Studies, Tamale, Ghana

2 Department of Agricultural Economics and Agribusiness, University of Ghana, Accra, Ghana

Published online: 05 November 2021

%), de retard de croissance (29,8 %) et d'insuffisance pondérale (25,2 %), mais elles suggèrent un meilleur état nutritionnel pour les enfants issus de ménages producteurs de cultures vivrières indigènes, par rapport aux enfants issus de ménages non producteurs. Les enfants issus de ménages producteurs ont un rapport taille-âge, poids-pour-taille et poids-pour-âge plus élevé que les enfants issus de ménages non producteurs. Les résultats suggèrent que les enfants issus de ménages non producteurs sont plus exposés au risque d'être chétifs, émaciés et en situation d'insuffisance pondérale par rapport aux enfants issus de ménages producteurs. L'exploration du lien empirique entre la production de cultures vivrières indigènes et l'état nutritionnel des enfants dans le nord du Ghana permet d'élargir la littérature sur la nutrition et la culture vivrière.

JEL Classification Q12 · Q15 · Q18 · C25

Introduction

Hunger and malnutrition have continued to receive much policy attention around the world; yet, progress has been relatively slow in reducing the number of people who suffer from the phenomena (Cuesta 2013). A recent global effort to address malnutrition in the Global Nutrition Compact (GNC) was conceived at the June 2013 Group of Eight (G8) Summit in Northern Ireland. The GNC was to mobilise US$4.15 billion to tackle malnutrition and promote nutrition-sensitive investments by the year 2020 (IFPRI 2013). Recent estimates of the World Food Programme (WFP) indicate that about 815[1] million people globally are malnourished with much of the organisation's interventions concentrated on child malnourishment and providing emergency relief services in conflict prone areas of the world. The Food and Agriculture Organisation (FAO 2014) reports that majority (98.2%) of the world's undernourished live in rural parts of the developing world and according to IFPRI (2013), 12.5% of the world's population are without adequate food calories with over 25% lacking required micronutrients.

Malnutrition weakens the human immune system, especially in children, making them susceptible to diseases, leading to mortality (Blössner and De Onis 2005) and this can affect human physical development and economic progress of nations. In Ghana, malnutrition affects mostly children and women and is concentrated in the northern parts of the country. Of the three most affected regions, the Northern Region is home to a large proportion of the undernourished (GSS 2014; IFAD 2013). The region has higher rates of under-five stunting, wasting and underweight compared to national estimates (GSS 2009, 2011, 2015). In 2014, with the exception of the nutritional deficiency of wasting, the Northern Region performed very poorly on all nutrition indicators in 2008 and 2014 and improvements in these indicators

[1] Accessed from https://docs.wfp.org/api/documents/WFP-0000016221/download/?_ga=2.214575125.306352121.1543124682-1425482959.1543124682 on 25th November 2018.

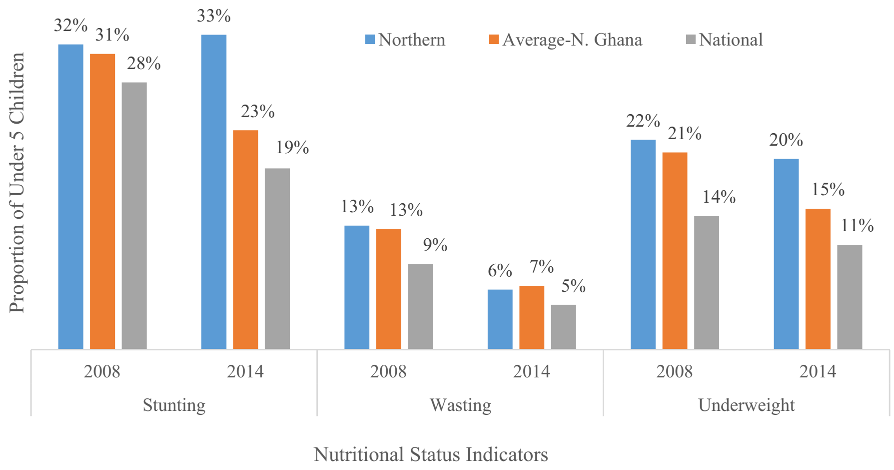


Fig. 1 Nutritional status of children; national and northern regional statistics. *Source* GSS (2009, 2015)

between 2008 and 2014 had also been slower in the region, except for wasting (Fig. 1).

Often, deficiency in protein, energy and micronutrients are the main drivers of poor nutritional status. These deficiencies are not traced to inadequate quantities of food consumed only but also to poor diet quality and diversity (FAO 2008; GSS 2009; Sibhatu et al. 2015; Sibhatu and Qaim 2018). Research indicates that the diets of resource poor households are of low quality because they are often comprised of starchy (energy dense) foods such as cereals and tubers and less of micronutrient dense vegetables, fruits and animal protein (Jones et al. 2014). With over 72% of households in northern Ghana engaged in smallholder farming (GSS 2012), current choices of food crops produced favour, a few energy-rich but micronutrient-deficient foods to the neglect of indigenous crop species which are good sources of non-animal protein and micronutrients (Chivenge et al. 2015; Ebert 2014; Sibhatu et al. 2015). In fact, these indigenous food crops are underutilised, and their increased production could help diversify diets and enhance the nutritional status of families in farm households. Indeed, several studies have suggested a positive effect of the production of diverse crops on household nutrition (Aboagye et al. 2007; Henson et al. 2013; Jones et al. 2014; Masters et al. 2013; Padulosi et al. 2014; Rajendran et al. 2014; Sibhatu et al. 2015).

Indigenous crops in the Northern Region consist of cereals (millet, sorghum and fonio); legumes or pulses (bambara nuts, cowpea, pigeon-pea and lentils); and vegetables and oil seeds (melon-seeds, sesame and assorted leafy vegetables) which are more suited for production in the region because of their adaptability to the local climate and soil conditions. In terms of protein content, indigenous crops are superior to crops such as maize, rice, cassava and yam (Ibok et al. 2014; Stadlmayr et al. 2012; Watson 1971). Probably, the high content of protein in these crops presents them as a good alternative source of non-animal protein. Indigenous vegetables and pulses are rich sources of vitamins, micronutrients and non-animal proteins while millets have high contents of amino acids compared to maize and rice (Ebert 2014; Tadele 2009).

Recent research linking diversified crop production and child nutrition status is scarce, but the few studies available suggest a significant empirical linkage between the two (Kumar et al. 2015; Lovo and Veronesi 2014; Malapit et al. 2015; Shively and Sununtnasuk 2015). Based on their findings of a significant positive association between farm production diversity and the height-for-age *z*-scores among children aged between 24 to 59 months, Kumar et al. (2015) concluded that improving child nutrition status could be achieved through diversifying agricultural production. Similar results were reported by Malapit et al. (2015) in Nepal where z-scores of weight-for-height of children were found to be positively associated with farmers' crop production diversity. In Tanzania, Lovo and Veronesi (2014) examined the effects of crop diversification on nutrition outcomes using a national level panel data for 2008 and 2010 collected on 3700 children and found a positive and significant effect of crop production diversity on children's height-for-age, especially for girls.

While research suggests a wide range of nutritional benefits of indigenous crops, a search for empirical evidence linking crop production diversity of indigenous food crops and household nutrition for Ghana and northern Ghana, in particular, revealed a gap in research in the area. This paper fills this knowledge gap by exploring the empirical linkage between crop production diversity with indigenous food crops and child nutritional status in farm households. The objective of the study is, therefore, to assess the impact of smallholder farmers' indigenous food crops production on the nutritional status of children in farming communities in northern Ghana.

Materials and Methods

Theoretical Framework

This paper relies on the agricultural household model to assess farm households' multi-cropping practices relative to their diverse crop production with indigenous crops (Benin et al. 2004) and the resulting effects on household nutrition (Kumar et al. 2015). The model presents the farm household as a representative economy where commodities are produced and consumed by its members (Benin et al. 2004; Kumar et al. 2015; Sadoulet and De Janvry 1995; Taylor and Adelman 2003; Van Dusen and Taylor 2005). As a representative economy, the household produces goods that are partly sold in the market and partly consumed by its members by using its endowed resources (including purachased inputs). The household production and consumption decision problem is then solved by maximising a utility function subject to an income constraint. From the household optimisiation process, an optimal indigenous crop output, Q^*, is obtained as a function of input prices P_j, w and farm characteristics K and this is specified in Eq. 1:

$$Q^* = f\left(P_j, w, K\right) \tag{1}$$

Under the assumption of imperfect markets, households' production and consumption decisions are inseparable, and optimal production and consumption decisions are determined not by observable market prices of inputs and outputs, but by shadow prices which serve as constraints (Sadoulet and De Janvry 1995; Taylor and Adelman 2003). To reflect such market imperfections in farming communities, a vector of household characteristics, D, is included to capture the effects of individual household members' preferences in household decisions on the production and consumption of farm output. The optimal indigenous crop output can then be re-stated in terms of farm production characteristics K and household characteristics D as in Eq. 2 based on which farm households' indigenous food crop production status was determined for empirical modelling.

$$Q^* = f(D, K) \tag{2}$$

Econometric Model

To assess the impact of indigenous food crop production by farm households and for our empirical modeling in this study, households were categorised as "producers" if they reported cultivating at least one or more indigenous food crops and "non-producers" if they did not produce such crops as explained based on Eq. 2. To this end, a latent variable indicating a household's indigenous food crop production status Q_i^*, is defined as a linear function of a vector of household and farm characteristics Z_i, assumed to affect households' decisions to produce indigenous food crops and $V_\mathbf{i}$, a random error term (Eq. 3).

$$Q_i^* = \delta Z_i + V_i \tag{3}$$

Equation 3 indicates that a household produced indigenous food crops in the year under study given that $Q_i^* > 0$ and the observable dichotomous variable, Q_i, indicates whether or not a household is a producer as specified in Eq. 4.

$$Q_i = \begin{cases} 1 & \text{iff } \delta Z_i + V_i > 0 \\ 0 & \text{iff } \delta Z_i + V_i \leq 0 \end{cases} \tag{4}$$

where $Q_i = 1$ indicates that the household is a producer and $Q_i = 0$ indicates otherwise.

Defining farm households' nutritional status to be a linear function of the production of indigenous food crops along with other observable variables, the linear regression equation can be specified as:

$$A_{ih} = \beta X_i + \gamma Q_i + U_i \tag{5}$$

where A_{ih} is the nutritional status indicator of the ith child in household h, X_i is a vector of household and household individual characteristics, Q_i as defined earlier, β and γ are vectors of parameters to be estimated while U_i is a random error term.

Using OLS techniques to estimate the impact of indigenous food crop production on children's nutritional status based on Eq. 5 may produce biased and inconsistent estimates. This is because, households' decisions to produce indigenous food crops is assumed exogenous by Eq. 5, but this could be endogenous[2] (Heckman 1979) since these decisions to produce or not to produce indigenous food crops may be voluntary and could be based on individual self-selection. Under such circumstances, the impact of households' indigenous food crops needs to be isolated from the observed and unobserved socioeconomic and farm variables that determine households' nutritional status and indigenous food crop production status. For example, unobserved factors influencing households' decision may include farmers' personal traits (ability and skills) (represented by V_i) could correlate with unobserved factors that influence the outcome variable (nutritional status) (represented by U_i), and this could result in biased and inconsistent coefficient estimates.

To address the possibility of misleading attribution due to sample selection bias that could arise from the voluntary nature of households' decisions regarding indigenous crops production, the treatment effect model is applied following Aakvik et al. (2005), Lewbel (2007) and Donkoh et al. (2016). The error terms, V_i and U_i are bivariate normal with mean zero and covariance matrix $\begin{bmatrix} \sigma & \rho \\ \rho & 1 \end{bmatrix}$ and the model is estimated using maximum likelihood techniques.

The treatment effect model assumes that the error terms in the selection and outcome equations, Eqs. 3 and 5 respectively, are correlated and the level of correlation is ρ, which indicates that unobserved factors that increase or decrease nutritional outcomes (z-scores) occur with unobserved factors that increase/decrease the probability of a household's indigenous crop production (Makate et al. 2016; Tsiboe et al. 2016). A test of the hypothesis that ρ is not statistically different from zero was conducted to compare the joint likelihood of a separate probit model for the selection equation and a regression model on the observed data against the likelihood of the treatment effect model. Results of a Wald test of independent equations under the null hypothesis show a $\chi^2 = 3.69$ ($p = 0.0588 < 0.1$) for height-for-age; $\chi^2 = 5.69$ ($p = 0.0171 < 0.05$) for weight-for-height; and $\chi^2 = 3.95$ ($p = 0.0468 < 0.5$) for weight-for-age. Therefore, we failed to reject the treatment effect model as appropriate. A goodness of fit test based on the Wald Test failed to accept the null hypothesis that all the independent variables included in the models are jointly equal to zero. The χ^2 ratios of 399.85, 81.41 and 398.14 for the respective models of height-for-age, weight-for-height and weight-for-age were all significant at 1% level, implying that at least one explanatory variable included in each of the models was non-zero.

Description of Variables

Indicators often used to assess the nutrition outcomes of segments of populations in empirical research include anthropometric measures (Cogill 2003; Gross et al. 2000;

[2] The Heckman approach estimates impact in two stages. The first stage involves probit, that estimates the determinants of respondents belonging to treatment. The second stage involves estimation of impact of the treatment on outcomes of interest, conditional on treatment assignment and other control variables and the predicted Inverse Mills Ratio (IMR) from the first stage.

Table 1 Summary of variables used in the analysis

Variable	Measurement	Expected sign
Height-for-age (haz)	Number	
Weight-for-height (whz)	Number	
Weight-for-age (waz)	Number	
Produced indigenous food crops	Dummy (1 = yes; 0 = otherwise)	+
Child's age in months	Number of months	±
Child's sex	Dummy (1 = male; 0 = otherwise)	±
Mother's education status	Dummy (1 = educated; 0 = otherwise)	+
Mother's age	Number of months	–
Exclusively breast fed	Dummy (1 = yes; 0 = no)	+
Experienced diarrhoea	Dummy (1 = yes; 0 = no)	–
Crop produced for home use	Dummy (1 = yes; 0 = no)	+
Household head education	Dummy (1 = educated; 0 = no)	+
Household head gender	Dummy (1 = male; 0 = female)	±
Household head age	Number of years	±
Household size	Number of household members	–
Young household members	Number of non-adult members	–
Livestock ownership	Dummy (1 = yes; 0 = no)	+
Market distance	Number kilometres	–
Karaga District	Dummy (1 = yes; 0 = no)	±
West Mamprusi	Dummy (1 = yes; 0 = no)	±

GSS 2011, 2015). Therefore, A_{ih} in Eq. 5, the outcome equation, represents a vector of children's anthropometric measures consisting of the *z*-scores of height-for-age (haz), weight-for-height (whz) and weight-for-age (waz) of sampled children. The *z*-scores of height-for-age (haz), weight-for-height (whz) and weight-for-age (waz) were estimated using WHO's Anthro software. In explaining child anthropometric indicators, the independent variable of interest was households' indigenous crop production, measured as a dummy variable taking the value "1" if the household produced indigenous food crops and "0", otherwise. A summary of variables used in the analysis is presented in Table 1.

It is hypothesised that participation in indigenous crop production has a positive effect on all selected nutrition outcome indicators. Household socio-economic and demographic factors as well as farm characteristics and institutional factors are included as control variables in the analysis. Other independent variables included as control variables were individual child and mother's demographic and socioeconomic characteristics selected based on previous empirical studies (Lovo and Veronesi 2014).

Sampling, Data and Data Collection

Using a multistage sampling procedure, three districts, Chereponi, Karaga and West Mamprusi in the Northern Region were selected in the first stage purposively because they were identified as areas where indigenous crops were being promoted. Based on the number of farm households engaged in crop farming in the three districts (GSS 2012), 390 farm households were sampled from 16 farming communities with five each from the Chereponi and Karaga Districts and six from the West Mamprusi District. From 250 farm households, questionnaires were administered to 102, 68 and 80 farm households, respectively, from the Chereponi, Karaga and West Mamprusi Districts. Participants were selected based on evidence that they had birth certificates and participation was limited to only children within the 12–59 months age group. Overall, 436 children were enumerated with 154 from Chereponi District, 134 form Karaga District and 148 from West Mamprusi District.

The data covered household socio-economic and demographic characteristics as well as farm characteristics which were included in the analysis as control variables. Children's biodata such as age (in months), weights (in kg) and heights (in cm) were taken using standard instruments obtained from the Chereponi District Health Directorate. Specifically, micro-tapes were used to measure children's height/length whilst electronic weighing scales were used to measure their weight. Research assistants who collected the data were trained on the use of the instruments with a pre-test exercise prior to actual data collection.

Results and Discussion

Descriptive Results

The descriptive results are presented in Table 2 and they are focused on child and household level demographic characteristics related to the outcome equation (Eq. 5) in line with the main objective of assessing the effect of the production of indigenous food crops on children's nutrition outcome indicators. Fifty-four percent (54%) of the sampled children were boys and sex distribution was similar across producers and non-producers. The average child aged 36.5 months for all households, 36.8 months for producer households and 35.9 months for non-producer households. The average child in the overall sample weighed 12.2 kg, but children in producer households weighed higher at 12.6 kg compared to 11.3 kg of their counterparts in non-producer households. Children's heights were also significantly different between the groups of producers and non-producers. The average child in producer households was taller (92.3 cm) than a child in non-producer households (87.9 cm), but the overall mean height was 91 cm. The overall mean (standard deviation) *z*-scores in terms of weight-for-height, height-for-age and weight-for-age were respectively −0.89 (1.08), −0.1.09 (1.5) and 1.20 (0.98). In all three cases, there were significant differences between producers and non-producers as children from producer households had better *z*-scores compared to children from non-producer households.

Mothers of children in non-producer households were a little older at 27 years than mothers in producing households whose average age was 26 years, but this difference was significant only at the 10% level. Seventeen percent (17%) of mothers had formal education, and there was no significant difference between

Table 2 Child and household level characteristics

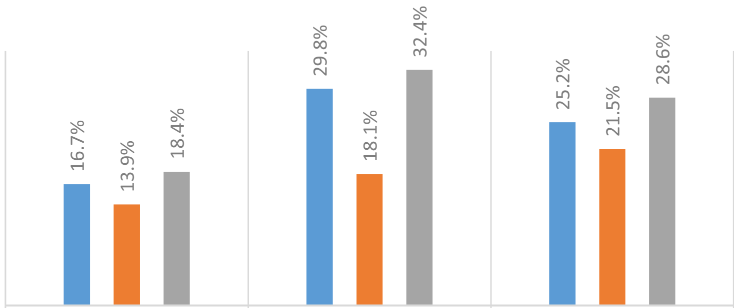
Characteristic	Producers	Non-producers	Total sample	Difference†
Child level characteristics				
Male child (%)	54.2	54.8	54.4	−0.12
Female child (%)	45.8	45.2	45.6	0.12
Child's age (mean)	36.8 (12.9)	35.9 (13.3)	36.5(13.0)	0.64
Child's weigh (mean)	12.6 (2.4)	11.3 (2.1)	12.2 (2.4)	5.21***
Child's height (mean)	92.3 (10.5)	87.9 (10.5)	91.0 (10.7)	4.0***
Weight-for height *z*-score (mean)	−0.83 (1.07)	−1.08 (1.09)	−0.89 1.08)	2.22**
Height-for-age *z*-score (mean)	−0.78 (1.3)	−1.9 (1.4)	−1.09 (1.5)	7.42***
Weight-for-age *z*-score (mean)	−0.98 (0.89)	−1.75 (0.95)	−1.20 0.98)	7.98***
Mother's education (%)	17.4	17.5	17.4	−0.01
Mother's age (mean)	26.5 (5.2)	27.4 (6.1)	26.7 (5.5)	−1.79*
Exclusively breast fed (%)	56.8	62.7	58.5	−1.12
Child had diarrhoea (%)	34.8	29.4	33.3	1.10
Household demographic and socio-economic factors				
Household size (mean)	9 (3.8)	7 (2.6)	8 (3.5)	4.82***
Age of household head (mean)	44 (13)	42 (13)	43 (13)	1.28
Household head education (%)	19.7	27.2	22.4	−1.63*
Male household head (%)	77.5	83.3	79.2	−1.02
Household members < 15 years (mean)	5 (2.3)	3 (1.5)	5 (2)	4.74***
Household owns livestock (%)	81.5	59.7	75.2	3.60***
Average market distance (mean)	8.4 (7.4)	5.6 (6.0)	7.15 (6.8)	3.83***

NB Robust standard errors are in parentheses

***, ** and * refer to Statistical significance of 1%, 5% and 10% respectively

†Differences in means and proportions between producers and non-producers were tested using the *t*-test statistic and the *z*-test statistic respectively

producers and non-producers in terms of mothers' educational attainment. Mean number of Antenatal Care (ANC) visits before delivery was 3.9 and this was the same for producers and non-producers. This implies that mothers had visited a health facility, on the average, 4 times before delivery, and this is in line with recommendations of the World Health Organisation (WHO 2006). Another good childcare practice considered in the analysis was exclusive breastfeeding. Majority (58.6%) of children were exclusively breastfed, but there were more (63.2%) children in non-producer households than those in producer households (56.8%). This finding of higher breastfeeding among non-producer households could be attributed to the fact that such households were relatively more urban compared to those in remote areas where primary health services was lacking. In terms of early childhood health related problems, about a third (33.1%) of sampled children were reported to have suffered from diarrhoea in the month prior to the study with a higher incidence among children from producer households (34.8%) compared to non-producer households (28.8%).



	Wasting	Stunting	Underweight
Total	16.7%	29.8%	25.2%
Producers	13.9%	18.1%	21.5%
Non-Producers	18.4%	32.4%	28.6%

Fig. 2 Prevalence of child malnutrition in farm households. *Source* Field Survey Data, May/June 2016

The prevalence rate of malnutrition in the study area was about 16.7% wasting, 29.8% stunting and 25.2% underweight for all children in the sample. These estimates are comparable to recent estimates of the prevalence rate of malnutrition among children under five in the Northern Region. The 2014 Ghana Demographic and Health Survey (GDHS) estimated stunting at 33.1% and underweight at 20%, whilst the Ghana Multiple Indicator Cluster Survey (GMICS) which preceded the 2014 GDHS reported that 37.4 and 24.2% of children in the region were, respectively, stunted and underweight (GSS 2011, 2015). Children's nutritional status according to households' indigenous crop production orientation is also presented in Fig. 2.

In all three cases of wasting, stunting and underweight, the rates of malnutrition were higher among children from non-indigenous crop producing households compared with the rates among children in producer households as indicated by Fig. 2. However, a two-sample test of difference in proportions revealed a statistically significant difference only for stunting between the two sub-groups.

Empirical Results: Indigenous Crop Production and Child Nutritional Status

The discussion of the results of the maximum likelihood estimation of the treatment effect model is limited to the nutrition outcome equation (Eq. 5). Results of the models are presented in Table 3. The variable of interest, households' production of indigenous food crops, is positive and significant in all three areas of child nutritional status indicators. These results indicate that the production of indigenous crops is positively and significantly associated with children's height given their age; weight given their height; and weight given their age. This suggests that households that produce indigenous crops might be well placed than those that do not to have adequate nutrient supply through the production of diverse food crops that include indigenous crops. Farm households that adopt indigenous food crops in their crop production strategies can be said to have diversified their food crop production and

Table 3 Determinants of child nutrition status-maximum likelihood estimates

Variables	Height-for-age		Weight-for-height		Weight-for-age	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Child's age in months	0.012***	0.004	−0.017***	0.004	−0.006**	0.003
Child's sex	−0.079	0.109	−0.165*	0.095	−0.130*	0.071
Mother's education	0.273*	0.147	0.025	0.133	0.148	0.101
Mother's age	−0.009	0.0108	0.009	0.008	0.004	0.006
Exclusively breast fed	0.145	0.119	0.446**	0.174	1.412***	0.101
Experienced diarrhoea	−1.907***	0.105	0.191	0.135	−1.092***	0.098
Crop production objective	−0.014	0.142	−0.043	0.129	0.102	0.109
Household head education	0.307**	0.150	0.267**	0.121	0.232**	0.093
Household head gender	0.196	0.154	−0.059	0.132	0.028	0.094
Household head age	−0.001	0.006	0.009**	0.004	0.005	0.004
Household size	−0.028	0.033	−0.023	0.026	−0.002	0.019
Young household members	0.011	0.047	−0.004	0.037	-0.011	0.025
Livestock ownership	−0.014**	0.005	−0.008	0.006	−0.013**	0.005
Market distance	0.002	0.011	−0.025***	0.007	-0.010*	0.006
Located in the Karaga District	0.192	0.183	0.018	0.139	0.037	0.107
Located in West Mamprusi	0.197	0.144	0.160	0.126	0.157*	0.095
Indigenous crop producer	**1.480*** **	**0.418**	**0.290** **	**0.139**	**0.69*** **	**0.175**
Constant	−2.090***	0.520	−1.157***	0.419	−2.828***	0.348
athrho	−0.523**	0.226	0.402***	0.151	−0.314*	0.171
lnsigma	0.176***	0.0600	−0.008	0.0340	−0.307***	0.035
Number of observations	436		436		436	

Source Field Survey, May/June 2016

SE robust standard errors

***, ** and * indicates Statistical significance at 1%, 5% and 10%, respectively

this finding is corroborated in recent studies on the empirical linkage between farmers' crop diversification and child nutritional achievements (Kumar et al. 2015; Lovo and Veronesi 2014; Malapit et al. 2015; Shively and Sununtnasuk, 2015). In a recent analysis of welfare implications of the adoption of Bambara nuts, an indigenous cropamong smallholder farmers in northern Ghana, William et al. (2016) concluded that farmers who adopted Bambara nuts had greater welfare in terms of per capita consumption compared with farmers who did not. In Nepal, Malapit et al. (2015) concluded that farm production diversity contributed positively to improved nutritional status of children in terms of weight-for-height *z*-scores.

The average treatment effect (ATE) of being an indigenous crop producer is the value of the coefficient of the treatment variable (producer) reported in the outcome regression. As demonstrated in the Stata Treatment-Effects Reference Manual (StataCorp 2015) and applied empirically by Makate et al. (2016), the size of the coefficient of the binary indicator of the production of indigenous crops is the average treatment effect. The results show that the production of indigenous food crops improves child wasting by 30%, underweight by 69% and as much as 150% in respect of stunting.

The study identifies other important determinants of a child's nutrition status. Children's height-for age or stunting is positively influenced by child's age, mother's education and the education status of household head, but negatively affected by child's health history in terms of prolonged diarrhoeal infection, age of household head and household ownership of livestock. The findings about child's age and mother's education relative to the height-for-age status of children are similar to previous empirical findings (Alom et al. 2009; Iram and Butt 2006a, b; Sassi 2014). The finding regarding effect of the incidence of diarrhoea is similar to that reported by Iram and Butt (2006a, b) that the nutritional calorie available for under five children in Pakistan reduced significantly with a history of diarrheal infection. Regarding weight-for-height (wasting), exclusive breast feeding, age of household head and his/her education status are the positive influencing factors with child's sex and distance to the nearest marketplace being the negative influential factors. The positive determinants of children's weight-for-age status (Underweight) are exclusive breast feeding, education, age of household head and being located in the West Mamprusi District. In contrast, child's age and sex, incidence of diarrhoea infection, livestock ownership and remoteness to markets tend to make child underweight worse.

Conclusion and Recommendations

Based on the findings in this study, it is concluded that the production of indigenous and underutilised food crops by farm households improves the nutritional status of children under five years of age but gains in this regard could be hampered if diarrhoeal infection is widespread. Other important determinants of children's nutritional status are mother's education, exclusive breast feeding, household headship and distance to the nearest market centre. It is therefore recommended that the benefits of indigenous food crops can be extended to the wider population through public campaigns targeting rural farming communities to adopt the production and hence consumption of indigenous food crops. A wider use of indigenous food crop products can be pursued through the development and marketing of well packaged assorted foods made from indigenous and underutilized food crops and made available in convenient and ready-to-use forms. This strategy will help ensure the availability of markets to take up any surpluses that could result from increased production.

Declarations

Conflict of interest All authors declare that there is no conflict of interest.

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Alhassan Andani (PhD) Applied Agricultural Economist and Senior Lecturer at the Department of Food Security and Climate Change, University for Development Studies, Tamale, Ghana.

John Baptist D. Jatoe (PhD) Agricultural Economist and Senior Lecturer, Department of Agricultural Economics and Agribusiness, University of Ghana, Legon, Ghana.

Ramatu M. Al-Hassan (PhD) Agricultural Economist and Associate Professor, Department of Agricultural Economics and Agribusiness, University of Ghana, Legon, Ghana.