The use of bullock traction technology for crop cultivation in northern Ghana: An empirical economic analysis

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Summary

THE ECONOMIC *impact of bullock traction technology (BTT) on the farming systems in northern Ghana is assessed. Crop production data were collected in three villages during the 1982/83 cropping season from 12 hoe-using and 30 bullock-using households. Comparative analysis of the hoe and the BTT farming systems indicates that BTT is technically and economically superior to hand-hoe technology, and that it offers a solution to the low agricultural productivity in the region. Households using BTT realised higher crop production and higher income compared to those using hand-hoe technology.*

Introduction

Northern Ghana is in the semi-arid zone of West Africa, and has one rainy season which normally begins in May and ends in September. It is dominated by smallholders who depend almost exclusively on the traditional hand-hoe technology for crop production, the majority of which is used for subsistence.

The unimodal rainy season, combined with the predominant hand-hoe technology, is a major problem for smallholder crop production in the region. Even though labour is abundant, availability during the short growing period is a critical constraint. Seasonal labour shortages are one of the main factors which contribute to low productivity, the primary agricultural problem in the area (NORRIP, 1982).

To increase the production of cash crops and at the same time solve the problem of seasonal labour shortages encountered by peasant farmers, BTT was introduced in the region around 1930 by the then colonial government (Kline et al, 1969). As in most parts of West Africa, the priority given to bullock traction technology for crop cultivation shifted with changes in agricultural policies. Shortly after Ghana won independence in 1957, the newly-elected Government decided that bullock traction technology did not fit its concept of modernising Ghana's agricultural sector through the use of tractors. Consequently, Government support for BTT stopped.

This policy change hindered further spread of the technology. Farmers who had already adopted BTT had problems getting spare parts, and those who were interested in adopting it had difficulty procuring equipment. However, aid agencies which were promoting BTT in the region continued to supply farmers with traction equipment purchased from neighbouring countries, but were not able to satisfy the growing demand. After long years of somewhat

frustrating experiences with tractors in the region, combined with a weak economy, new attention has been directed to BTT by the Government.

Even though BTT has survived in northern Ghana since it was first introduced, and is apparently beneficial, no effort has been made to investigate its economic impact on farming systems in the region. This paper analyses data collected from farmers in parts of northeastern Ghana, and compares the traditional hand-hoe and BTT farming systems for both technical and economic efficiency. Although the data in this analysis are from a limited area, the information is valid for other areas using BTT.

The role of BTT in raising productivity

Crop production in much of the semi-arid and arid zones of Africa is affected by the unimodal rainy season and the predominant hand-hoe technology. In these areas, land preparation cannot take place during the dry season because the soils are too dry to be worked, and farmers must wait until the beginning of the rainy season before they can start land preparation.

Because the rainy season is usually short, land clearing, seedbed preparation and planting must be accomplished quickly to ensure the highest production possible. Farmers invariably face labour shortages during the limited time they have for these operations. In households where the increased labour demand cannot be satisfied, planting can be finished on time by reducing the cropped area, or the required operations are completed late. In both cases, the economic performance of the household is negatively affected.

Because bullock-using farmers can work faster on a given unit of land than the hoe households, they can use the time saved for new tasks, such as manuring, application of chemical fertilizers and thorough weed control, which are crucial to improving agricultural productivity. Moreover, they are in a better position to increase the number of crops grown on a single piece of land.

As a result of improved agronomic practices, productivity is expected to be higher under bullock farming than under hoe farming (Jäger, 1984). In areas where arable land is abundant, the time saved through BTT can be used to expand the cultivated area. Crop production will rise because of the extra output from the additional land brought under cultivation. Other benefits of changing from hand-hoe technology to any form of animal traction are reduced labour requirements per unit output and increased cropping intensity.

The study area

The data in this paper were collected in three villages (Nakpanduri, Sakogu and Gbingbalanchet) in the northeastern part of northern Ghana from April 1982 to March 1983 (Panin, 1986). These settlements are inhabited mostly by people from the Mamprusi, Bimoba and Konkomba ethnic groups. Unlike in many parts of northern Ghana, the population density in the northeast is high. Even though the exact figure is not available, there is an indication that the area is approaching population saturation (NORRIP, 1982), which is supported by Tripp (1982) who reported that the population density in some parts of northeastern Ghana exceeds 150 persons km^{-2} compared with 17 persons km^{-2} for the whole region (Central Bureau of Statistics, 1984).

The climate of the area is similar to that throughout northern Ghana. The rainy season is from June to September, and the average monthly temperature is about 30° C, with a maximum of 33° C recorded in March. The vegetation of the area is characterised by grass and scattered trees.

Farming technology is still traditional; most farmers till their land with the traditional hand-hoe, but the use of animal traction is familiar in the area. About 20% of the farming population uses BTT, but only for ridging (Panin, 1986). Bullocks are the main draught animals used by the farmers. Unlike in other parts of West Africa where animal traction studies have been undertaken, no animal traction project had ever been established in the study villages before the farmers adopted BTT for crop cultivation.

In the study area, as well as throughout northern Ghana, farmers cultivate two types of farmland; the compound farm, which surrounds the house, and bush farms, which may be located up to several kilometres from the house. The compound and the bush farming systems are based, respectively, on the principles of permanent and shifting cultivation (Benneh, 1973; Diehl and Runge-Metzger, 1985). Chemical fertilizers are known to the farmers, but are rarely used for crop production because supplies are both inadequate and irregular.

Method

During the year of investigation, data were collected from 42 randomly selected farming households. Twelve of these households were classified as hoe farmers, since they did not own draught animals and almost exclusively used the hoe for seedbed preparation. The other 30 households belonged to the animal traction group. Each had at least one pair of bullocks which were used to prepare seedbeds for almost all the cultivated land. The sample was stratified into three groups according to the experience acquired from the use of the animal traction technology in order to evaluate the impact of this experience on farmers' performance (see Panin, 1986). For this reason, the animal traction sample was purposely over represented.

The hoe sample was chosen from 492 hoe households from all the three villages. Similarly, the bullock sample was selected from 122 bullock households. Data were collected through direct measurement, observation, and formal and informal interviews. The frequency of the interviews depended on the nature of data required. During the survey period, each plot was mapped, measured, and the crops grown were recorded, as was daily labour. Household labour, non-household labour, and farming operations performed by each category were recorded separately. The labour record did not include the time spent walking to and from the fields.

Crop yield estimates were recorded in local units of measure (baskets, pans and bowls), as indicated by the households during the triweekly visits of enumerators. A sample of the containers was randomly selected and the contents were weighed to establish kg per container. Later in the analysis, total crop output of each plot was converted into kilocalories (kcal) to provide a common basis to measure the different crops grown on a plot. Yields of minor crops, and their share of total cultivated area per household, were excluded from the analysis. Minor crops were yam, cassava, sweet potatoes, okra, tobacco, aubergine and pepper.

Household income and expenses were obtained through weekly records of sales and purchases. Income from non-farm activities was recorded monthly. In order to have uniform prices for the evaluation of food purchases and sales, prices of food crops were recorded every

market day. Since food commodities were sold by local volume measures, the kg equivalent of these measures was established each time the price was recorded.

Characteristics of the sample households

Both hoe and bullock households were large, polygamous, and had a high level of illiteracy. Bullock households were larger, with an average of 14.5 members compared to 10.8 in the hoe households (Table 1). When the number of workers was compared, either in terms of adults (defined as persons aged 16–55 years) or total labour capacity, bullock households had a larger labour force than the hoe households. The total labour capacity of a household was derived by using a weighting system to convert all household members from the age of six into standard man-working equivalents. The respective mean differences of household size and number of workers between the two groups of households were highly significant (Table 1).

Table 1. *Characteristics of hoe and bullock households, northeast Ghana, 1982/83.*

Characteristic	Hoe system (c.v.)[1]	Bullock system (c.v.)
Number of households	12	30
Average household size	10.8 (33)	14.5* (35)
Average age of household head	49.3 (27)	59.0* (23)
Average number of wives per household	1.3 (36)	2.1* (44)
Average number of adults per household	3.7 (32)	6.1** (44)
Total labour capacity (ME)[2]	5.8 (38)	8.9** (34)
Household composition (%)		
Males		
0–15years	31.0	27.0
16–55years	13.2	18.0
Over 55 years	3.1	5.1
Females		
0–15 years	26.4	20.4
16–55 years	21.7	23.2
Over 55 years	4.7	5.5
Formally educated 3 household members (%)	8.5	9.2
Cultivated area (ha) of which	3.7 (60)	6.4** (46)
% ridged with bullocks	8.2	74.9
% ridged with hand-hoe	39.8	3.4
% ploughed with tractor	12.1	0.5
% not ridged	39.9	21.2
Number of cattle owned	1.5 (235)	17.3** (93)
Households owning at least one cow or ox (%)	25.0	100.0

[1] c.v. = coefficient of variation (%).
[2] Derived by using a weighting system to convert all members in the household from the age of 6 years into standard man-working equivalents (ME):

	Age group (years)			
	6–9	10–15	16–55	
Male	0.25	0.85	1.00	0.61
Female	0.20	0.69	0.85	0.52

[3] Defined as having at least 6 years of primary education.
Significance levels: * = P<0.05; ** = P<0.01.

In the bullock sample, the household heads were older. The adoption of BTT correlated with the age of the household head. In the analysis, the correlation coefficient, while significant (P< 0.05), was only 0.32. Age was a principal motive for 37% of the heads to shift from hand-hoe technology to BTT. Since cattle are kept more for security than for farming, it is most likely that the household heads, who control the cattle, release bullocks for cultivation only when they are too old to use the hoe for seedbed preparation.

The average number of cattle per bullock household was 17.3 compared to 1.5 per hoe household (Table 1). While every household in the bullock sample owned at least one cow or ox, 75% of the hoe households had no cattle. With only one exception, bullock households owned cattle before adopting BTT for crop cultivation, which indicates that the first farmers to adopt BTT were those who already had cattle.

Impacts of BTT

Cultivated area

The area cultivated per hoe household ranged from 1.4 to 7.4 ha, with an average of 3.7 ha. The average area cultivated per bullock household was 6.4 ha with a range of 1.3 to 10.5 ha (P<0.01). About 75% of the cultivated area of bullock households was ridged with bullock traction compared to only 8% of that of hoe households (Table 1).

Any major increase in average cultivated area per bullock household is usually assumed to be an effect of BTT, but in many cases households using BTT have a larger labour force (Table 1), and thus the increased area may be due to a difference in scale. Because of differences in family size, the real impact of BTT on cultivated area is assessed using a land/resident ratio, i.e. a ratio that reflects the relative factor intensity of the production technology being used (Crawford, 1982).

The average cultivated area is defined both in terms of hectares per household member and per adult (Table 2). Cultivated area measured both ways was greater for bullock households. On a per member basis, the bullock farmers cultivated 20% more land than the hoe farmers, but the mean difference was not statistically significant. Per adult, the bullock households cultivated

only slightly more land (4%) than the hoe households, which again was not statistically significant. These figures compare closely to the findings of Barrett et al (1982).

Table 2. *Average cultivated area per resident for hoe and bullock households, northeast Ghana, 1982/83.*

	Hoe households		Bullock households		Area difference (%)
	Area (ha)	c.v.[1] (%)	Area (ha)	c.v. (%)	
Area cultivated per household member	0.35	62	0.44	55	+26
Adult	1.01	61	1.05	56	+4

[1] c.v. = coefficient of variation.

According to the analysis, BTT did not cause any significant change in the area cultivated per adult worker. This can be traced to the individual motives of the farmers for adopting BTT: only 27% said that the ability to farm more land was a motive, while the majority of the bullock farmers reported that larger farm areas increase the demand for labour to weed and harvest the crop if the technology package does not include weeding and harvesting equipment. The correlation between total cultivated area and the annual labour input in man-hours was 0.39 ($P < 0.01$) for weeding and 0.84 ($P<0.01$) for harvesting, which supports the farmers' views.

Cropping patterns

Nineteen crops were grown in the study area. Based on the percentage of the total cultivated area planted with each crop, eight are considered major in both the hoe and bullock farming systems: millet (early and late), maize, sorghum, groundnuts, cowpeas, bambara nuts and *nari* (a sesame variety) (Table 3). Millet, maize and sorghum are the major food crops in the area, while the others are cash crops, of which groundnuts are the most important.

Table 3. *Percentage of area planted to different crops by hoe and bullock households, northeast Ghana, 1982/83.*

Crop	Percentage of area planted	
	Hoe households	Bullock households
All cereal crops	79.6	73.9
Millet (early and late)	33.8	29.5
Sorghum	12.6	9.6
Maize	33.2	34.8
All cash crops	19.1	24.6
Groundnuts	10.3	17.7
Cowpeas	6.5	3.4
Bambaranuts	1.5	2.6
Nari (sesame variety)	0.8	0.9
Others[1]	1.3	1.5

[1] Okra, pepper, garden eggs (aubergine), tobacco, sweet potatoes and yams. The cultivated areas of these crops are usually very small.

There was little difference between the two groups in the area planted to the major food crops, and in both systems these crops predominated – almost 80% for the hoe households and 74% for the bullock households. The bullock households had 5.5% more land under cash crops. BTT had only a small effect on the cropping pattern and does not appear to put the staple food crops at risk.

Mixed cropping systems

The 19 individual crops were usually grown in mixtures (Table 4). Bullock households allocated slightly more land to mixed crop enterprises than the hoe households. While farmers planted between two and five crops on a piece of land, the majority of the land (64% for hoe households and 54% for bullock households) was planted to only two crops.

Table 4. *Percentage of cultivated areas planted to multiple crops, northeast Ghana, 1982/83.*

	Percentage of cultivated area	
	Hoe households	Bullock households
Number of crops planted per field		
1	19.1	13.9
2	63.6	53.6
3	6.6	21.7
4	10.7	9.1
5	0.0	1.7
All crop mixtures	80.9	86.1

Of particular interest was the crop diversification in the bullock households. The bullock households allocated as much as 33% of their total cultivated area to mixtures of three or more crops, while the area covered by such crop mixtures in the hoe farming systems was only 17%. This relatively high level of diversification among the bullock farmers is consistent with one of their reasons for adopting the technology; 60% of the bullock sample said that diversification was a motive for BTT adoption. The bullock farmers were able to achieve greater diversification than their hoe-using counterparts because of per hectare labour time saved from ridging and planting operations.

Crop yields

The effect of BTT on crop yield is not clear. Reports from experiment stations show that crop yields increase on animal traction farms (Eicher and Baker, 1982; Pingali et al, 1987), but evidence from farmers' fields indicates only modest yield increases (Lassiter, 1982). In this study, bullock households had average yields of 3327 kcal ha^{-1}, while those of the hoe farmers averaged 2861 kcal ha^{-1}, a 16% difference (Table 5: $0.01 < P < 0.20$).

Table 5. *Average crop yields[a] of hoe and bullock farms, northeast Ghana, 1982/83.*

	Average yield (kcal ha^{-1})	c.v.[b] (%)	Yield difference (%)
Hoe households	2 860.9	49	
Bullock households	3 327.2	27	+ 16.3

[a] Yields of minor crops are excluded (see Table 3, footnote).
[b] c. v. = coefficient of variation.

Regression analysis was done to determine the potential impact of BTT on crop yields at the plot level (Table 6). The analysis at this level also eliminates any underestimate of the BTT yield effect due to hoe farmers borrowing bullocks for ridging and/or to a failure of bullock farmers to ridge all their plots with BTT. Its results show that BTT had a positive impact on the level of crop

yield (P< 0.01). This contrasts with most studies on animal traction which did not show any significant yield effect (Pingali et al, 1987).

Table 6. *Estimate of the relationship between yield of all crops from both hoe and bullock households and selected factors which influence yields[a], northeast Ghana, 1982/83.*

Independent variable	Regression coefficient[b]
Labour input (ME-h ha^{-1})[c]	0.184 (3.695)**
Seed input (¢ ha^{-1})[d]	0.000 (0.020)
Use of bullock traction (dummy, 0–1)	0.321 (8.005)**
Number of crops in a mixture	0.257 (3.496)**
Fertilizer input (kg ha^{-1})	0.013 (2.407)**
Intercept	6.243
No. of observations	249
Overall F-ratio	23.202**
R^2	0.32
Adjusted R^2	0.31

[a] Cobb-Douglas production function: dependent variable is yield per hectare of all crops measured in kilocalories.
[b] Figures in parentheses are student T-values of regression coefficients. Significance level: ** = P<0.01.
[c] ME-h = man-equivalent hour.
[d] ¢ = cedi (in 1982, ¢ 2.75 = US$ 1).

Labour use for field work

Total labour use per farm was greater in bullock than in hoe households (Table 7). On an average hoe-using farm, the total average annual labour input per hectare was 568 ME-hours, while on an average bullock farm it was 625 ME-hours. The mean difference was not statistically significant, but the result contrasts with those of similar studies (e.g. Barrett et al, 1982).

Table 7. *Average labour use per farm and per major farming operation, northeast Ghana, 1982/83.*

Farming operation	Hoe farms		Bullock farms	
	Av. labour[a] (ME-h ha^{-1})	c.v.[b] (%)	Av. labour (ME-h ha^{-1})	c.v. (%)
Clearing	39.9	80	48.4	55
Ridging	42.0	78	28.1 *	40
Planting	77.6	45	69.9	43
Weeding	208.9	50	229.7	73
Harvesting	192.5	43	233.2	37
Mounding[c]	0.3	268	3.1[+]	175
Fertilizer application[d]	6.7	178	12.4	279
Total	567.9	29	624.8	38

[a] Average labour is given in man-equivalent hours (ME-h).
[b] c.v. = coefficient of variation.
[c] Mounding and fertilizer application are not major farming operations in the study area. Mounding is done for yam cultivation which, unlike in other areas of northern Ghana, does not play any significant role in the study area.
[d] Fertilizer application depends on quantity and timely delivery. As observed in the study area, the supply of fertilizers was usually late, irregular and inadequate.
Significance levels: * = $P< 0.05$; + = $P< 0.10$.

The use of BTT significantly reduced the per hectare labour requirement for ridging from 42 ME-hours under the hand-hoe farming system to 28 ME-hours ($P< 0.05$). Per hectare labour requirement for planting was also reduced, but the mean difference was not statistically significant. On the other hand, bullock farmers had higher clearing, weeding and harvesting labour requirements per hectare than the hoe farmers. However, none of the mean differences were statistically significant.

The overall increase in labour-use intensity on the bullock farms should not be surprising, because besides ridging, which benefits most directly from the use of BTT, all the other operations are performed manually. The drop in labour input for planting is an effect of ridging, because planting or sowing is faster on ridged plots than on flat land.

Increased labour requirements for clearing, weeding and harvesting may be explained as follows:

- The shift from hand-hoe to bullock traction technology requires that land be cleared more thoroughly. The usual practice in hoe farming is to burn the vegetation and leave the stumps and roots, whereas with BTT, stumps and roots must be removed to avoid potential damage to both implements and animals. The extra work initially increases the labour per hectare to clear the land, but this effect is likely to disappear after the first 2 years.
- Deeper ridging enables both crops and weeds to grow faster, thus increasing the need for weeding on bullock farms. In addition, more diverse crops may also require more labour for weeding.
- The higher crop yields achieved under bullock farming require more harvest labour.

A linear regression analysis, which included farm size, household labour force, and the use of BTT (a dummy variable) as independent variables and labour intensity as dependent variable (Table 8), showed that overall, the use of BTT did not significantly affect the total labour input per hectare.

Table 8. *The influence of farm size, total labour capacity and bullock traction use on labour intensity, northeast Ghana, 1982/83.*[1]

Independent variable	Regression coefficient [2]
Farm size (ha)	–66.79 (–4.498)**
Household labour capacity (ME)	37.30 (2.923)**
Use of bullock traction (dummy)	56.37 (0.684)
Intercept	634.04
No. of observations	42
Overall F-ratio	7.38**
R^2	0.37
Adjusted R^2	0.32

[1] Dependent variable is total man-equivalent (ME) hours per hectare used for field work.
[2] Figures in parentheses are student T-values of regression coefficients. Significance level: ** = P< 0.01.

Variations in labour intensity are explained by the first two variables only. The regression coefficient of farm size was negatively related to labour intensity, whereas household labour capacity was positively related. The regression coefficients for both variables were highly significant (P<0.01).

Annual labour input of household members

shift from hand-hoe technology to BTT for crop cultivation changed the labour input of individual household members. On average, males in the bullock households worked more hours than their counterparts in the hoe households, even though the mean differences were not statistically significant (Table 9). The greatest increase was among elderly men (over 55 years) in the bullock households, who worked an average of 63% more hours. This is attributed to the overall increase in labour requirements for harvesting.

Table 9. *Annual labour input by household members in different sex-age categories, northeast Ghana, 1982/83.*

Sex-age category	Hoe households		Bullock households	
	Labour (ME-h $year^{-1}$)[a]	c.v.[b] (%)	Labour (ME-h $year^{-1}$)	c.v. (%)
Males				
10–15 years	142.5	158	227.0	80
16–55 years	426.1	60	450.1	54
Over 55 years	126.7	158	206.2	102
Females				
10–15 years	53.3	74	43	146
16–55 years	229.1	69	201.6	59
Over 55 years	41.1	292	75.7	129
Man equivalent of household member	290.9	49	323.9	39
Household head	401.6	42	382.7	72

[a] ME-h = man-equivalent hour.
[b] c.v. = coefficient of variation.

The annual labour input from 10–15 year-old boys in the bullock households was 59% more than that contributed by boys in the hoe households. This increase, which has also been identified by Norman et al (1981), is because with the introduction of BTT the boys are used to lead the bullocks during ridging. Active male workers (16–55 years) in the bullock households worked only 16% more hours than the same age group in the hoe households.

In contrast to boys and active men, girls (10–15 years) and active women (16–55 years) in the bullock households worked on average fewer hours than the same groups in the hoe households (Table 9). The mean differences were not statistically significant. However, the data do not confirm the view of several writers (e.g. Boserup, 1970; Tinker, 1976) that new agricultural technologies may increase women's workload and reduce those of men.

As was the case with elderly men, elderly women in the bullock households spent on average more hours working on the farm than did their counterparts in the hoe households, but the mean difference was not statistically significant (Table 9).

When all labour in a household is considered in terms of man-working equivalents, each man-equivalent in the bullock households spent on average 11% more hours working on the farm than did each man-equivalent in the hoe households. The annual labour supplied by the heads of hoe households was higher than that of the bullock household heads, which is a function of their age difference and the differences in the consumer/worker ratio, as well as in the number of adults per household (Panin, 1986).

Household income

The economic evaluation of hoe and bullock households is based on the 1982/83 farm household income statement (Table 10). Crop production is by far the largest source of household income in both farming systems, accounting for 76% in the hoe households and 73% in the bullock households. Trading, processing and gathering of agricultural produce is the next most important source of income in both types of household –20% in the hoe households and 13% in the bullock households. Income from livestock enterprises is third.

Table 10. *Summary of annual farm household income and returns to production for hoe and bullock households, northeast Ghana, 1982/83.*

	Hoe households		Bullock households	
	Income (¢)[a]	c.v [b] (%)	Income (¢)	c.v. (%)
Income				
Total gross value of crop production	79 951.7	55	152 868.7**	(45)
Value unsold	70 951.7		134 563.0	
Value sold	8 080.5		18 305.7	
(Production costs)	(7 492.8)	(60)	(11 363.6)*	(48)
Net revenue (A)	71 539.4	58	141 505.1**	48
Other net income[c] (B)	18 532.1	118	25 867.2	99
Livestock (C)	2 020.3	109	14 968.7**	74
Net farm income (A+B+C)	92 091.8	54	182 341.0**	42
Income from other sources	1887.3	161	11 587.3**	132

(D)				
Total net household income (A+B+C+D)	93 979.1	51	193 928.3**	41
Returns to production				
Returns to household labour				
Net production income				
per man-equivalent (¢ ME^{-1})a	12 630.2	45	16 728.2	46
per active worker (¢ ME^{-1})	19 708.9	45	26 371.0	51
per ME-h[e] of household labour (¢ ME-h^{-1})	48.3	59	53.3	34
Net farm income				
per man-equivalent (¢ ME^{-1})	16 403.6	46	21 570.7^{+}	41
per active worker (¢ ME^{-1})	25 182.1	42	35 291.1	57
Net household income				
per man-equivalent (¢ ME^{-1})	16 850.3	44	22 794.9*	38
per active worker (¢ ME^{-1})	25 761.2	39	37 419.4^{+}	56
Returns per unit of land (¢ ha^{-1})				
Net crop production income	20 831.8	29	26 646.8*	32
Net farm income	28 824.0	46	35 513.3	34
Net household income	29 835.7	45	38 203.1^{+}	38

[a] ¢= cedi (in 1982, ¢ 2.75 = US$ 1).
[b] c.v. = coefficient of variation..
[c] Income from trading, processing and gathering agricultural produce.
[d] ME = man-working equivalent.
[e] ME-h = man-equivalent hour
Significance levels:$^{+}$ P <0.10; * = P< 0.05; **P< = 0.01.

Agricultural trading, processing and gathering is the major source of cash income in both the hoe-using (66%) and the bullock households (35%). Crop production ranks second for the hoe households (15%), but livestock enterprises are second for the bullock households (26%) (Table 11). Average net income from crop production and average total net income were higher for the bullock households.

Table 11. *Summary of annual statement of cash income for hoe and bullock households, northeast Ghana, 1982/83.*

Source	Hoe households		Bullock households	
	Net cash (¢)[a]	c.v.[b] (%)	Net cash (¢)	c.v. (%)
Crop production	3 042	326	11 190	155
Livestock enterprise	2 020	109	14 969**	74
Trading, processing and gathering of agric. produce	13 699	188	20 054	87
Other sources	1 887	161	11 587*	132
Net cash income per				
Household	20 648	(83)	57 800**	61
Household member	1 912	(82)	3 986**	50

[a] ¢ = cedi (in 1982, ¢ 2.75 = US$ 1).
[b] c.v. = coefficient of variation.
Significance levels: * = P< 0.05;** = P< 0.01.

To eliminate the influence of land and labour availability on the absolute net incomes, both systems were compared on the basis of returns to land and labour. Bullock farmers had 23–28% more income per hectare and, with one exception, their returns to labour were 32–45% higher (Table 10).

Most household income is from crop production, but only a small portion of the total harvest is sold. A summary of the annual cash income, which is relevant for the adoption of BTT, is presented for both groups of households in Table 11. Net cash income per household was ¢ 20 648 in the hoe farming system and ¢ 57 800 in the BTT system (P<0.01). On a per caput basis, the difference was still large and statistically significant (P< 0.01) – ¢ 3986 per bullock household member and only ¢ 1912 per hoe household member.

Conclusions

Comparative analysis of the hoe and the BTT farming systems in northern Ghana indicates that households using BTT realised higher crop production and higher income compared to those using the traditional technology. Farmers changed from hand-hoe technology to BTT to reduce labour bottlenecks and shorten field work time, but this was difficult to achieve because the package is limited to ridging.

It is recommended that the technological package be improved to include traction implements for sowing, weeding and harvesting. In addition, farmers should be taught to diversify the use of draught animals for other labour-intensive and time consuming household activities usually performed by women, such as transportation of water and firewood. And last but not least, government policy should be geared towards the provision of credit with reasonable repayment conditions to enable peasant farmers purchase bullocks. It is very likely that when these recommendations are followed, the adoption rate of BTT in the region will increase, and, consequently, the living standard of smallholders will improve.

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