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FINANCIAL ECONOMICS | RESEARCH ARTICLE

Profitability and profit efficiency of certified groundnut seed and conventional groundnut production in Northern Ghana: A comparative analysis

Dominic Tasila Konja^{*1}, Franklin N. Mabe¹ and Richard Oteng-Frimpong²

Abstract: This study seeks to compare profitability and profit efficiency of certified groundnut seed (CGS) and conventional groundnut (CG) production in Northern Ghana using cross-sectional data. The two-step stochastic metafrontier profit model was used to estimate profit efficiencies and their determining factors for CGS and CG producers. The study found that CGS production is more profitable and profit efficient than CG production. Whilst profit efficiency of CGS is influenced by age, education, extension visits, Farmer-Based Organisation meetings, and farming experience, profit efficiency of CG producers is influenced by educational status, access to extension, and access to mobile phone. To increase profit and profit efficiency, the capacity of CGS producers should be built to incentivise them to upscale CGS production so as to bridge the demand deficit in the country. Also, farmers should be trained to enter into CGS production.

Subjects: Economics; Finance; Industry & Industrial Studies



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PUBLIC INTEREST STATEMENT

Unlike in the case of rice and maize, production of certified groundnut seed (CGS) is not encouraging in Africa. In Ghana, some effort has been made by research institutes including Savannah Agricultural Research Institute to develop the groundnut seed system. However, research has shown that most of the seed producers rather concentrate on conventional groundnut (CG) seed production with very few producing CGS. Therefore, this study seeks to investigate the profitability and profit efficiency in groundnut seed production in Northern Ghana. The study found that CGS producers are more profitable and profit efficient than CG producers in the study area. Empirical findings from the study confirm that groundnut seed producers' socioeconomic characteristics and institutional and market variables significantly affect their profit and profit efficiency level in production. The study recommends that the capacity of CGS producers should be built to motivate them increase production to bridge the supply deficit in the country.

Keywords: Profit efficiency; two-step stochastic metafrontier profit model; certified groundnut seed and conventional groundnut

1. Introduction

Since agriculture is and remains key for economic growth, the need to enhance agricultural output and productivity becomes important in Ghana. Population growth in many developing countries continues to widen the gap between food production and demand, necessitating major improvement in productivity. The relationship between the world population growth and the agricultural growth was first postulated by a pessimist economist Thomas Malthus in 1803. Malthus pointed out that an exponential increase in population cannot be sustained in the long run since land and other natural resources are fixed in supply. Considering this, there is a growing concern about the ability of some nations, especially in sub-Saharan Africa, to produce enough food to be self-sufficient.

According to World Bank (2012), countries that have undertaken initiatives to expand producers' access to agricultural technologies such as improved and certified seeds and fertilisers have generally been the most effective at increasing agricultural productivity. Seed, fertiliser, and irrigation are the three most critical inputs for enhancing crop productivity in developing countries (Abay, Berhane, Taffesse, Abay, & Koru, 2018). Among the three, seed is the cheapest way to go for a successful green revolution (AGRA, 2018). According to Alliance for a Green Revolution in Africa (AGRA) (2014) in a survey of farmers in nine African countries, majority of farmers who invested in improved crop varieties achieved yields 50–100% above local variety. Regardless of the positive impact of seed in crop production, in most countries (e.g. Ghana, Cameroon, Ethiopia, Tanzania, and Uganda), the progress of seed industry has been very limited in spite of investment and assistance (AGRA, 2014).

The seed sector in Ghana was privatised in 1990 because it is generally accepted that the private sector would be more efficient in the production and supply of seed relative to the public sector. It was expected that the private sector would usher in a period of efficient, widespread, and profitable seed programme. This is yet to materialise, and currently, less than 5% of Ghanaian farmers get access to improved seed from approved sources. The Ministry of Food and Agriculture (MoFA) believes that Ghana's agricultural achievements could be improved if its seed sector is developed (MoFA, 2015).

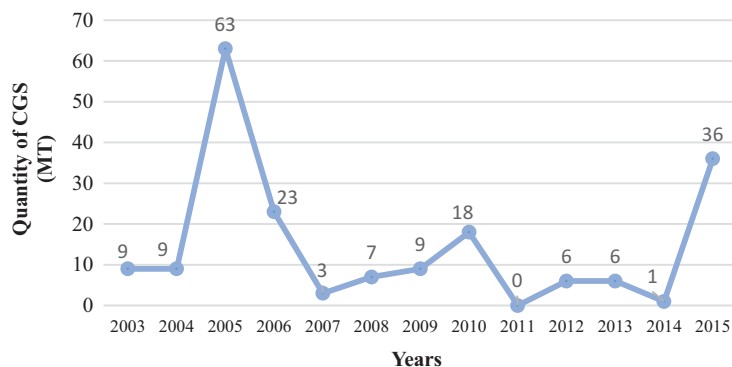
Currently, the seed sector focusses on few crops such as rice, maize, sorghum, and soybeans. Other crops like groundnut have poorly developed seed systems. Groundnut is one of the key oil crops in the country; meanwhile, there is no crop subsidy for its seed production relative to other crops such as rice, maize, and soybeans. Although some efforts have been made by research institutes including Savannah Agricultural Research Institute (SARI) to develop the groundnut seed system, improved seed use rates remain low and inconsistent (AGRA, 2017; Ibrahim, Florkowski, & Kolavalli, 2012). Two parallel market systems exist for groundnut seed in Ghana, namely, the conventional or informal and the formal seed market. It has been observed that majority of groundnut seed producers rather dominate in the informal market than the formal market. Many farmers engaged in groundnut production do so with local varieties purchased from the informal market due to the fact that supply is less compared to demand (Etwire et al., 2013; Tripp and Mensah-Bonsu, 2013).

From Figure 1, the quantity of certified ground seed produced from 2003 to 2015 has been fluctuating. According to Tripp and Akwasi-Mensah (2013), the fluctuation can be attributed partly to weather, demand, and support from various government and donor projects and the fact that there are small-scale producers engaged in the sector. The question remains, is formal groundnut seed production not profitable and profit efficient?

The formal seed market for other crops such as rice, maize, and soybeans is well developed in the country than its conventional seed market, increasing farmers' access to good planting

Figure 1. Certified groundnut seed production in Ghana, 2003–2015.

Source: Plant Protection and Regulatory Services Directorate (PPRSD) and NASTAG.



material for crop yield improvement. In the case of the groundnut seed system, it is rather otherwise, where the majority of the production is being done conventionally. Although some effort has been made by research institutes including SARI and National Seed Trade Association of Ghana to develop formal seed industry, the concentration has been limited for groundnut. The questions that arise are whether certified groundnut seed (CGS) production is profitable and profit efficient as compared to conventional groundnut (CG) production. This study focussed on the formal sector while the majority of the producers are in the informal sector because the formal sector produces good quality planting materials relative to the informal sector. According to Hasanuzzaman (2015), CG seed producers supply farmers with a mixture of varieties, diseased seed, and low-yielding varieties. Mixed varieties may mature at different times which lead to problems in harvesting and post-harvest handling and result in lower yields (Hasanuzzaman, 2015). Conversely, CGS producers are formally registered, with their activities monitored and regulated by the Plant Protection and Regulatory Services Directorate (PPRSD) in the country. This regulatory body ensures that CGS producers strictly produce seeds of superior attributes and well packaged before distributed to farmers (Etwire, Ariyawardana, & Mortlock, 2016). Aligned certification schemes reduce the risk of disease transmission, guaranteeing a reliable germination, seed purity, and uniformity (GTZ, 2015).

The need to upscale CGS production to meet the demand of the market is very paramount. Meanwhile, a sustainable supply of CGS by the formal seed producers to the market can effectively be achieved if their production is highly efficient and profitable than the conventional producers. An improvement in the understanding of the levels of profit efficiency between CGS and CG seed producers and its determining factors can greatly aid policymakers in creating efficiency-enhancing policies as well as in judging which way to go for a successful green revolution. To this effect, the main objective of this research is to compare profitability and profit efficiency of CGS and CG production in Northern Ghana. Specifically, the study seeks to:

- (1) estimate and compare the profit levels of CGS and CG producers.
- (2) estimate and compare the benefit–cost ratio (BCR) of CGS and CG producers.
- (3) identify the factors that influence profit levels of CGS and CG producers.
- (4) estimate the profit efficiencies of CGS and CG producers and their determining factors.

2. Hypotheses of the study

The following hypotheses were tested and validated.

H₁: Formal or CGS production is more profitable than the CG production.

H₁: Each of the factors such as unit price of output, quantity of output, wage of labour, price of seed, price of weedicide, and farm size affects the profit level of groundnut seed production.

H₁: Formal or CGS producers are more profit efficient than the CG producers.

H₁: Each of the factors such as sex, age, farming experience, marital status, education level, household size, Farmer-Based Organisation (FBO) membership, and extension contact affects the profit efficiency levels of groundnut seed producers.

3. Literature review

3.1. Seed production in Africa

The need to increase agricultural productivity to feed the ever-growing population in the world is a key concern of both developed and developing countries. However, the Asian Green Revolution that began in the 1960s as a result of the development and dissemination of high-yielding varieties improved access to fertiliser coupled with state-supported subsidies, rural credit, and better infrastructure contributed to strong productivity growth in major staple crops. Hence, sub-Saharan Africa is also replicating the Asian Green Revolution through the development and dissemination of improved agricultural technologies. The implementation of strong intellectual property rights in agriculture on the continent is a key feature of the Green Revolution push, as it is assumed that this is the only incentive that will draw in private sector breeders (World Bank, 2015). Seed in this regard is the first and foremost source of all food and an important input in agricultural production. Seeds are a valuable asset not only to farmers but also to the global society. Hence, efforts towards a world without hunger must inevitably target seed system development. Figure 2 shows a gradual growth in seed production in Africa from a period of 2007 to 2013.

Nigeria leads in the production of seed with 22,684.7 Mt and followed by Ethiopia (15,833.0 Mt), Uganda (14,600.8 Mt), Burkina Faso (3,543.1 Mt), Ghana (1,356.5 Mt), Tanzania (8,283.6 Mt), and Mozambique (3,158.6 Mt), among others (AGRA, 2014). Meanwhile, not many countries have adequately addressed the question of providing farmers with sufficient quantities and good quality seed. Several countries in Africa, for example, yearly seed demand surpasses production. In 2016, the total seed demand of six major crops (in Table 1) in West Africa was 1,193,876 Mt, but only 268,454 Mt was supplied (WASP, 2016). According to Niangado (2010), the trend of demand for improved varieties of seed is not always predictable. Smallholder farmers' adoption of improved crop varieties in sub-Saharan Africa is amongst the lowest in the world (estimated to be 20% by the Alliance for a Green Revolution in Africa (AGRA), 2017). In the case of some countries in West and Central Africa, farmers only ask for seed under the following situations: following a disaster; when their own varieties are not performing well; and when they want to test new varieties

Figure 2. Seed production in Africa, 2007–2013.

Source: AGRA (2014).

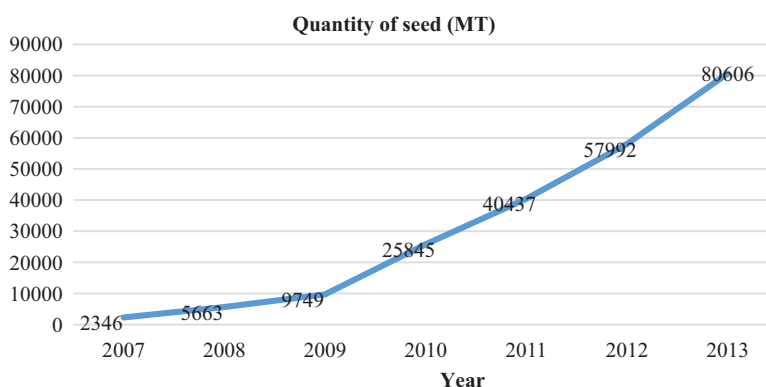


Table 1. The seed demand and supply of six major crops in West Africa

Crops	Seed demand (Mt)	Seed supply (Mt)	Seed deficit (Mt)	% Need met (Mt)
Maize	173,160	75,665	-97,495	44
Rice	204,110	100,822	-103,288	49
Sorghum	88,799	7,599	-81,200	9
Millet	60,992	24,162	-36,830	40
Cowpea	177,878	3,799	-174,079	2
Groundnut	488,937	56,408	-432,529	12
Total	1,193,876	268,454	-925,422	22.49

Source: WASP (2016).

Table 2. Description of variables in two-step stochastic metafrontier translog profit model

Variables	Description	Measurement	A priori Expectation		
			CGS	Conventional	Pooled
Ps	Natural price of seed	Ghana cedi (GH¢)	-	-	-
Pw	Price of weedicide	Ghana cedi (GH¢)	+	+	+
PL	Price of labour	Ghana cedi (GH¢)	-	-	-
PQ	Price of output	Ghana cedi (GH¢)	+	+	+
K	Value of capital input	Ghana cedi (GH¢)	-	-	-
Fs	Farm size	Acreage	+	+	+
Q	Acreage	Ghana cedi (GH¢)	+	+	+
Age	Age of respondents	Number of years	±	±	±
Sex	Sex of respondents	Dummy (male = 1 & female = 0)	-	-	-
MStat	Marital status of respondents	Dummy (married = 1 & otherwise = 0)	-	-	-
AxEdu	Access to education	Dummy (educated = 1 & otherwise = 0)	-	-	-
EduYrs	Years in education	Number of years	-	-	-
Hhs	Household size	Number of persons	+	+	+
Exp	Farming experience	In years	-	-	-
NumFBOMet	FBO membership	Dummy (member = 1 & not member = 0)	-	-	-
AxExt	Access to extension service	Dummy (yes = 1 & no = 0)	-	-	-
NumExtVisit	Number of extension visit	Dummy (accessed = 1 & not accessed = 0)	-	-	-
AxMob	Access to mobile phone	Dummy (yes = 1 & no = 0)	-	-	-

following an advertisement or a research day. Table 1 shows the total quantity of seed demanded, seed supplied, and seed deficit for six selected major crops in West Africa in 2016.

Table 1 sanctions the need for Africa to upscale seed production especially for groundnut, cowpea, and rice since their demand deficits are high. The seed systems in most sub-Saharan Africa countries focus on a narrow band of crops, principally maize, rice, and sorghum. Less attention is paid to grain legumes, tuber crops, and horticultural crops. Low production of seeds in sub-Saharan Africa and other countries in the world has substantially increased their seed importation to meet farmers' demand. For instance, in 2013, African countries imported about 40,000 tonnes of field crop and vegetable seed, whereas countries in Asia imported 79,000 tonnes (Cairns et al., 2013). Farmers' access to quality seed of diverse range of adapted cultivars is still hampered by insufficient and inefficient seed production and distribution systems, poor seed quality assurance, inadequate seed policies, and seed price (Kifla & Atilaw, 2018; Etwire et al., 2016; Singh, Prasad, & Reddy, 2013; Barnett, Chisno, & Pinto, 2011). The challenges for seed production which exist currently in developing countries will upsurge with climate change (Das et al., 2019; Singh et al., 2013). The programme for Africa's seed system is seeking to encourage the development of seed systems that deliver improved, locally adapted crop varieties to small-holder farmers and uptake and use of released cultivars (Alliance for a Green Revolution in Africa (AGRA), 2017, and Barnett et al., 2011).

There exist two parallel seed systems in Ghana: a formal system established by the government and its technical partners and a traditional (conventional) or informal system centred on a tradition of exchanges and mutual support among farmers within any one zone (Niangado, 2010). The formal system is characterised by the production and purchase of commercial certified seed, while the informal sector is based on seed production and exchange among farmers at the local level (Lyon & Afikorah, 1998). The formal seed system is purposively composed of separate activities to provide new varieties, maintain their purity, certify the seeds, and distribute them to farmers, usually through officially recognised seed outlets. The informal seed system is basically what the formal system is not. In the informal system, seed-related activities tend to be integrated and locally organised without being regulated under any national law. The National Seed Committee and National Seed Service Agencies that are part of the MoFA operate the formal system for certified seed. The MoFA has primary regulatory oversight over the seed sector and exercises oversight over the formal seed sector.

There are about 1,500 certified seed producers in Ghana, all of which are privately owned, and each year, about 150 certified seed growers produce improved seeds (World Bank, 2012). The private sector's role in Ghana's seed system is increasing, with private companies actively involved in seed multiplication and sale, yet much activity remains in the public sector, including varietal development. In Ghana, the failings of the seed industry are manifested in weak institutional linkages and unclear mandates, inadequate collaboration among participating partners, poor oversight arrangements, and inadequate resources to support both public servicing agencies and the fledgeling private seed production and supply entities (MoFA, 2015).

3.2. Theoretical review of metafrontier analysis

The theory of production is used to explain metafrontier analysis. The metafrontier analysis was first conceptualised and used by Hayami in 1969. In the study to determine the sources of agricultural productivity gap among selected countries, Hayami (1969) first mentioned metaproduction function. Two years later, Hayami and Ruttan (1971) defined metaproduction function as the "envelope of commonly conceived neoclassical production functions". Technically, the commonly conceived neoclassical production function is the production function obtained from firms producing a common output by using homogeneous technology, inputs as well as producing under the same environmental conditions within the same period of time. A production function is a technical relationship which shows the maximum physical output that can be produced from a given level of factor inputs given the technology at a particular time period. Undisputedly, Huyami and Ruttan are the official pioneers of the concept of metaproduction function. Meanwhile, Huyami and Ruttan acknowledged that the original conceptualisation of metafrontier is inherent in the early works of Salter (1960) and Brown (1966). In a research to determine

agricultural productivity across countries, Ruttan, Binswanya, and Hayami (1978) defined “Metaproduction function as the envelope of the production points of the most efficient countries“. The theory of metafrontier analysis is based on the fact that firms in different industries, regions, and/or countries face different opportunities (O’Donnell, Rao, & Battese, 2008). Instead of the homogeneous assumption of production technology, resource endowments, and climatic conditions made by Farrell (1957) about firms, it is possible to have the opposite assumptions. The contributions of early researchers to the development of metafrontier analysis cannot be underestimated.

The metaproduction function was modified by Hayami and Ruttan in 1970. Afterwards, it was adopted and empirically used to analyse and compare agricultural productivity across countries (Hayami & Ruttan, 1971). 1970 As there is frontier production function and frontier cost function, there is also metafrontier production function and metafrontier cost function. However, Ali and Flinn (1989) argued that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments. It is possible to evaluate group-specific firm performance in terms of cost relative to all the group cost performance. Metafrontier cost function envelopes all individual group-specific cost frontier. The use of metafrontier cost model in agricultural research is limited. However, few researchers have applied a rather stochastic metafrontier production model in their studies.

For example, Mabe, Donkoh, and Al-hassan (2018) used a stochastic metafrontier production model to analyse rice productivity heterogeneity among agroecological zones in Ghana. The researchers compared the metafrontier technical efficiency among three ecological zones in Ghana (i.e. Guinea savannah zone, coastal savannah zone, and forest savannah zone). The study revealed that farmers in Guinea savannah zone outperformed others, recording the highest average metafrontier technical efficiency score of 76.35%, followed by farmers in forest savannah zone and coastal savannah zone with average metafrontier technical efficiency scores of 76.16% and 75.11%, respectively. Huang, Huang, and Liu (2014) also found that even though firms in developed countries have higher technical efficiency, their counterparts in developing countries have the highest metafrontier technical efficiency. Mensah and Brummer (2016) also analyse the determinants of MD2 adoption, production efficiency, and technology gap in the Ghanaian pineapple production sector using stochastic metafrontier model. The study used cross-sectional primary data from two systems of pineapple production (i.e. organic and conventional systems). The result shows that pineapple farmers across the organic and conventional systems produced averagely 95% of the potential output, given the current technology available to the pineapple sector. The researchers found an average meta-technology ratio of 95%, which implies that both production systems’ performance is near the industrial frontier, with only 5% performance lag. Even though farmers under the conventional production system achieved a slightly higher average output of 97% with respect to their group frontier, their output performance still lags behind the industrial performance with a 5% technology gap which is the same for those farmers operating under the organic system. This suggests that farmers using either systems faced the same or similar problem in the production environment, preventing them from reaching the full industrial output potential. They also found that the average efficiency score of farmers in the organic production system relative to the metafrontier was smaller (89%) than in the conventional system (93%).

Bahta, Baker, Malope, and Katjiuonu (2015) also analysed the determinants of technical efficiency in beef farm in Botswana. The researchers used a stochastic metafrontier model followed by a Tobit regression model to estimate technical efficiency and meta-technology ratios and assess factors influencing the efficiency of a suite of beef farm types in Botswana. Results show that the average technical efficiency level is 0.496 for the whole sample and 0.355, 0.463, and 0.571 for beef farms who engage in cattle only, cattle and crop, and cattle, crop, and small stock farming, respectively. Again, Onumah, Onumah, Al-Hassan, and Brümmer (2016) also adopted metafrontier model to analyse organic and conventional cocoa production in Ghana. The results

reveal that the organic systems exhibit an increasing return to scale, whilst the conventional system exhibits decreasing returns to scale. All the input variables positively influence the production except the age of trees. The combined effects of operational and farm-specific factors are identified to influence the technical efficiency although the individual effects of some variables are not significant. The mean technical efficiency relative to the metafrontier is estimated to be 0.59 for the organic and 0.71 for the conventional farms. The study concludes that the conventional system of cocoa production is more technically efficient than the organic system. However, the use of metafrontier cost analysis in research is scanty. This study seeks to analyse profitability and profit efficiency of CGS and CG production in Northern Ghana. This will enable the research that recommend the efficient system for groundnut seed production to improve productivity.

4. Materials and methods

4.1. Study area

The study was conducted in Northern Ghana. Northern Ghana includes the upper east, northern, and upper west regions in this case. The three regions cover a total land area of 97,666 km² with an estimated population of 3,317,478 in 2010 (GSS, 2012). The main vegetation is grassland, interspersed with Guinea savannah woodland, characterised by drought-resistant trees such as *acacia*, *mango*, *baobab*, *shea-nut*, *dawadawa*, and *neem*. More than 80% of the inhabitants of Northern Ghana are full-time farmers (MoFA, 2011).

4.2. Data collection and sampling procedure

The data were collected from primary sources through field survey, mainly from CGS and CG producers. A four-stage sampling method was employed. In the first stage, a simple random sampling technique was used to select northern and upper east regions from Northern Ghana for the study. In the second stage, districts within the sampled regions were stratified into two (i.e. districts with and without CGS producers) where two and four districts were randomly selected from upper east and northern regions, respectively. In the third stage, two communities each from districts with and without CGS producers were selected using simple random sampling technique totalling 12 communities in all. In the last stage, 100 CGS and 150 CG producers were selected with the help of simple random sampling technique.

4.3. Data analysis

The study employed descriptive statistics, inferential statistics, and profit and stochastic meta-frontier models to analyze the data, and the results presented in the form of tables and charts.

4.3.1. Profit levels of CGS and CG productions

The profit levels of both CGS and CG producers were estimated separately, compared, and statistically tested for validation of the outcome. Profit is the surplus remaining after the deduction of total cost from total revenue. Mathematically, the profit of *i*th farm or *i*th firm is given as:

$$\pi_i = TR_i - TC_i \quad (1)$$

But, $TR = PQ$

$$TC_i = TVC_i + TFC_i \quad (2)$$

$$TVC_i = P_{labor}Q_{labori} + P_{seed}Q_{seedi} + P_{weedicide}Q_{weedicidei} + P_{plowing}Q_{acresi} \quad (3)$$

where π represents profit level of the firm, TR is the total revenue, TC is the total cost, TVC is the total variable cost, TFC is the total fixed cost, and P and Q are the prices and quantities of variable inputs, respectively.

The depreciated value of fixed inputs such as cutlass, big hoe, small hoe, knapsack sprayer, sacks, and a pan was calculated using a salvage value of zero since farmers cannot make use of

these inputs after their useful life. The straight-line depreciation method was employed to calculate depreciation as follows and incorporated into Equation (5):

$$D_{ji} = \frac{OV_{ji} - SV_{ji}}{E_{ji}} \quad (4)$$

where D_{ji} represents the depreciated value of the j th asset used by i th farmer, OV_{ji} is the original value of the j th asset used by i th farmer, SV_{ji} is the salvage value of j th asset used by i th farmer and it is assumed to be zero, and E_{ji} is the useful life of the j th asset used by i th farmer.

$$TFC_i = D_{cutlass_i} + D_{Bhoe_i} + D_{Sm_hoe_i} + D_{Pan_i} + D_{knasak_i} + D_{sacks_i} \quad (5)$$

After the estimation of the profit levels of both CGS and CG producers, a Student's t -test was used to test their statistical difference. Due to the fact that the sample size is unequal and the fact that the variances are assumed to be unequal, Welch's t -test was used to test the hypothesis that mean profit and BCR of CGS producers are greater than CG producers (Welch, 1947). The Welch's t -test can be specified as:

$$\text{Welch's } t \text{ - test} = \frac{\bar{\pi}_{CGS} - \bar{\pi}_{CG}}{\sqrt{\frac{S_{CGS}^2}{n_1} - \frac{S_{CG}^2}{n_1}}} \quad (6)$$

A statistically significant difference of the mean profit and BCR between CGS and CG producers would support the hypothesis that CGS production is more profitable than CG production. Therefore, CGS production should be encouraged in the study area.

4.3.2. Benefit-cost ratio in groundnut seed production

The BCR analysis was employed to determine whether groundnut seed production is economically feasible or not. A BCR attempts to identify the relationship between the benefits and cost observed by groundnut seed producers in the study area. The BCR of groundnut seed producers can be calculated as,

$$BCR = \frac{\sum TR_i}{\sum TC_i} \quad (7)$$

Decision rule:

BCR > 1, it implies that the firm is profitable.

BCR < 1, it implies that the firm is at loss.

BCR = 1, it implies that the firm has breakeven.

The decision rule is that the project is worth undertaking when the BCR is greater than one and vice versa. But the project will breakeven when the BCR is equal to one.

4.3.3. Theoretical framework: two-step stochastic metafrontier profit model

The two-step stochastic metafrontier profit model is underpinned by the theory of production. The root of metafrontier production function is the single production frontier introduced by Farrell (1957). Hayami (1969) talks of the metaproduction function which is a single production function that envelopes two or more individual production functions of firms producing using different technologies or operating under different environmental. In the case of this study, both CGS and CG producing firms are operating with different production technologies. Farrell's (1957) efficiency estimation using stochastic frontier analysis assumes a homogeneity production technology for all decision-making units in that industry. According to Battese, Rao, and O'Donnell (2004) and O'Donnell et al. (2008), it is irrational to compare the profit efficiencies of firms operating with different set of technologies. An analytical framework capable to separate the effect of technology

heterogeneity from profit inefficiency is required. The stochastic metafrontier technique is hereby appropriate since it is an improved estimation approach over the classical stochastic frontier analysis. The metafrontier is assumed to be a smooth function that envelopes all the frontiers (i.e. frontier of CGS and CG producing firms).

The two-step stochastic metafrontier profit model was used in this study in response to the observation of Huang et al. (2014) that estimating metafrontier by pooling data from a group of firms using different technologies is incorrect. Following Mabe et al. (2018) and Huang et al. (2014), separate stochastic translog frontier profit models were estimated for both CGS and CG producing firms. The predicted profits from the two firms were pooled together and used to estimate the stochastic translog metafrontier profit model. According to Huang et al. (2014), the two-step metafrontier model makes sure that all the group frontiers are enveloped by the metafrontier frontier, thereby making sure that the estimates are exact.

4.3.4. Empirical two-step stochastic metafrontier profit model

Profit efficiency in this context is defined as the ability of a farmer to achieve the highest possible profit given the prices of inputs and levels of fixed factors production. From the theory of production, profit (π_i) depends on quantity of output (Y), output price (P), and input prices w_j . Profit function is given as:

$$\pi_i = \pi_i(P, Y, w_j) \tag{8}$$

Due to certain factors emanating from the farmers themselves and some outside their control, they operate below the frontier profit function. The stochastic profit frontier for analysing profit efficiency of groundnut producers can be specified as:

$$\pi = \pi(P_Q, Q, W_l, P_{sed}, P_w, K, Fs)\varepsilon \tag{9}$$

But the composed error term (ε) = $V_i - U_i$

The observed group-specific stochastic profit model is given as

$$\pi = \pi(P_Q, Q, W_l, P_{sed}, P_w, K, Fs)(V_i - U_i) \tag{10}$$

The empirical two-step stochastic metafrontier translog profit model for identifying the factors influencing the profit levels of i th groundnut seed producer and estimating metafrontier profit efficiencies and their drivers is specified as:

$$\begin{aligned} \ln \hat{\pi}_i = & \beta_0 + \beta_1 \ln P_l + \beta_2 \ln P_w + \beta_3 \ln P_s + \beta_4 \ln P_k + \beta_5 \ln P_Q + \beta_6 \ln Q_i \\ & + \beta_7 \ln F_s + \frac{1}{2}\beta_{11} \ln P_l^2 + \frac{1}{2}\beta_{22} \ln P_w^2 + \frac{1}{2}\beta_{33} \ln P_s^2 + \frac{1}{2}\beta_{44} \ln P_k^2 \\ & + \frac{1}{2}\beta_{55} \ln P_Q^2 + \frac{1}{2}\beta_{66} \ln Q_i^2 + \frac{1}{2}\beta_{77} \ln F_s^2 + \beta_{12} \ln P_l \ln P_w \\ & + \beta_{13} \ln P_l \ln P_s + \beta_{14} \ln P_l \ln P_k + \beta_{15} \ln P_l \ln P_Q + \beta_{16} \ln P_l \ln Q_i \\ & + \beta_{17} \ln P_l \ln F_s + \beta_{23} \ln P_w \ln P_s + \beta_{24} \ln P_w \ln P_k + \beta_{25} \ln P_w \ln P_Q \\ & + \beta_{26} \ln P_w \ln Q_i + \beta_{27} \ln P_w \ln F_s + \beta_{34} \ln P_s \ln P_k + \beta_{35} \ln P_s \ln P_Q \\ & + \beta_{36} \ln P_s \ln Q_i + \beta_{37} \ln P_s \ln F_s + \beta_{45} \ln P_k \ln P_Q + \beta_{46} \ln P_k \ln Q_i \\ & + \beta_{47} \ln P_k \ln F_s + \beta_{56} \ln P_Q \ln Q_i + \beta_{57} \ln P_Q \ln F_s + \beta_{67} \ln Q_i \ln F_s + V_i - U_i \end{aligned} \tag{11}$$

where π is the normalised profit level, P_Q is the unit price of output, Q is the quantity of output, P_l is the wage of labour, P_s is the cost of seed,

P_w is the price of weedicide, K is the capital, and F_s is the farm size. U represents the profit inefficiency in production, $1 - U$ is the profit efficiency in production, and V denotes the stochastic noise as a result of estimation errors and climate variability in production.

The model estimating the determinants of profit inefficiency is given as:

$$U_i = \alpha_0 + \alpha_1 \text{Sex}_i + \alpha_2 \text{Age}_i + \alpha_3 \text{Mstat}_i + \alpha_4 \text{AxEdu}_i + \alpha_5 \text{EduYrs}_i + \alpha_6 \text{Hhs}_i + \alpha_7 \text{Exp}_i + \alpha_8 \text{AxMob}_i + \alpha_9 \text{NumFBOMet}_i + \alpha_{10} \text{NumExtVisit}_i + \alpha_{11} \text{AxExt}_i \quad (12)$$

5. Empirical results and discussion

5.1. Disaggregated descriptive statistics by CGS and CG producers

In Table 2 there is no statistically significant difference in some socioeconomic characteristics between CGS and CG producers. These are age, household size, years of education, farming experience, price of weedicide, price of labour, capital, total cost, and profit.

Statistically, more males and females are involved in CG production than CGS production. While 54.4% of the females producing CG, 45.6% are CGS producers. For males, 65.6% are CG producers, and this percentage is statistically higher than 34.4% producing CGS. Also, while CGS producers cultivated 1.7 acres of groundnut, CG producers cultivated 2.1 acres. This suggests that acres of land cultivated by CG producers are statistically larger than that of CGS producers. This revelation was expected as Tripp and Akwasi-Mensah (2013) noted that only 0.05% of all peanuts planted in the country in 2011 were certified.

The price of CGS (GH¢10.2) is statistically higher than the price of CG (GH¢8.3). The average price of groundnut seed purchased by CGS is statistically higher than that of CG producers. This is because CGS is of good quality than CG. It was found that CGS producers statistically sold

Table 3. Disaggregated descriptive statistics by CGS and CG producers

Variables	Mean		
	CGS producers	CG producers	Difference
Household characteristics			
Age (years)	42.32	40.61	1.71
Female (n = 125)	45.6	54.40	-8.80*
Male (n = 125)	34.40	65.60	-31.20*
Household size	8.44	7.44	1.00
Years in education	2.75	2.44	0.31
Farming experience	12.09	13.08	-0.99
Production and market variables			
Farm size (acres)	1.70	2.12	-0.42***
Price of seed (GH¢)	9.97	9.56	0.41***
Price of weedicide (GH¢)	12.45	10.44	2.01
Price of labour (GH¢)	7.16	7.32	-0.16
Price of output (GH¢)	10.15	8.28	1.87***
Capital (GH¢)	33.66	35.74	-2.08
Quantity of output sold (kg)	220.68	158.01	62.67***
Quantity of output (kg/acre)	337.58	251.90	85.68***
Total cost of production (GH¢)	412.35	465.54	53.19
Total revenue from produce (GH¢)	1330.89	822.76	508.13***
Profit (GH¢)	661.94	528.29	133.65
Profit/acre (GH¢)	410.98	216.27	194.71***

Note: *** Significant at 1% and * significant at 10%.

Source: Field survey (2018).

a larger quantity of output (220.9 kg) compared to their counterparts (158.0 kg). This means that CGS production is more market oriented than CG production. From the table, CGS producers obtained higher output (337.6 kg/acre) than their counterparts (251.9 kg/acre). Also, as CGS producers got higher revenue per acre (GH¢1330.9/acre), their counterparts who produced CG obtained lower revenue per acre (GH¢822.8/acre). The study indicates that, as CGS producers got a higher profit per acre (GH¢411.0/acre), their counterparts who produced CG obtained lower profit per acre (GH¢216.3/acre). This implies that CGS production is more profitable than CG production.

5.2. Benefit–cost ratio among groundnut seed producers

Figure 3 shows the frequency distribution of BCR score of CGS and CG producers. From the figure, the majority (54.0%) of CGS producers recorded BCR score >1 relative to 43.0% of CG producers, implying that more than half of CGS producers obtained profit. This means that their total revenue obtained is greater than the total cost of production.

The study also indicates that while 30.0% of CGS producers recorded BCR score equal to 1, 36.0% of CG producers recorded BCR equal to 1. Suggesting that, more CG producers break even than CGS producers. This means that their total revenue obtained is equal to the total cost of production. Lastly, the majority (20.7%) of CG producers recorded BCR score less than 1 relative to 16.0% of CGS producers. This suggests that more CG seed producers incur losses than CGS producers in production.

Table 4 illustrates Welch’s t-test for BCR between CGS and CG producers. The study observed that there is a statistical difference in BCR scores between CGS producers and CG producers. Although both CGS and CG production are profitable, however, CGS producers recorded higher BCR score of 2.29 as compared to their counterparts (CG producers) who obtained a BCR score of 2.05. The study observed an average BCR difference score of 0.61 between CGS and CG producers, which is statistically significant at 1%.

5.3. Determinants of profit

Table 5 shows the maximum likelihood estimates for parameters of the two-step stochastic metafrontier translog profit. The table shows separate models for CG and CGS producers. It also shows the metafrontier model which was estimated by using predicted profits from the group-specific frontiers. Following Coelli, Rao, O’Donnell, and Battese (2005), all the variables were normalised through mean correction and hence can be interpreted as partial elasticities. Since the sums of respective models’ first-order coefficients are positive, the monotonicity condition is met.

The result of CG producers’ model shows that, apart from the price of seed and wage of labour which were statistically significant at 5%, quantity of output, price of output, and farm size were all significant at 1%. The study noted that wage of labour, price of seed, and farm size negatively

Figure 3. Benefit–cost ratio (BCR) of groundnut seed producers.

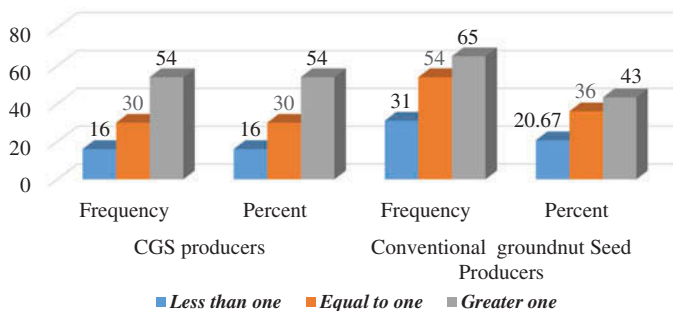


Table 4. Welch's t-test for BCR between CGS and CG producers

Category of farmers	Observation	Mean BCR	Standard error
CG producers	150	2.0462	0.1056
CGS producers	100	2.6574	0.1738
Total	250	2.2907	0.0958
Difference =		-0.6112	0.1920
Welch's t-test = -3.1839			
p-Value (T<t) = 0.0008***			

Source: Field survey (2018).

Table 5. Maximum likelihood estimates of two-step stochastic metafrontier translog profit model

Variables	Conventional groundnut seed producers		CGS producers		Pooled	
	Coefficient	Standard error.	Coefficient	Standard error.	Coefficient	Standard error
LnProfit (main model)						
lnPw	-0.071	0.291	-1.158**	0.459	-0.296	0.190
lnPL	-0.649**	0.327	9.628**	4.091	-0.419**	0.192
lnPs	-0.905**	0.474	0.566	1.977	-0.638**	0.311
lnK	0.072	0.092	-3.409***	0.916	0.024	0.070
lnPQ	1.954***	0.495	180.306***	68.209	1.778***	0.339
lnQ	2.151***	0.144	1.315**	0.543	2.154***	0.094
lnFs	-0.824***	0.151	12.343***	3.155	-0.831***	0.103
lnPL ²	-0.096	1.016	-3.059***	0.922	-0.551	0.637
lnPw ²	0.012	0.138	0.255**	0.128	-0.094	0.089
lnPs ²	-1.617	1.618	-0.239	2.584	-0.848	1.065
lnK ²	0.052	0.070	-0.190	0.140	0.038	0.056
lnPQ ²	-0.722	1.142	-729.511***	242.754	-1.160	0.916
lnQ ²	-0.747***	0.218	-0.626***	0.176	-0.839***	0.125
lnFs ²	-0.192	0.218	0.037	0.327	-0.434***	0.147
lnPLlnPw	-0.211	0.285	0.697**	0.276	0.129	0.152
lnPLlnPs	-1.410	1.521	-9.053***	3.474	-1.396	1.204
lnPLlnK	0.970***	0.365	2.357***	0.584	0.678**	0.296
lnPLlnPQ	-0.564	1.315	-100.040**	40.643	0.075	1.064
lnPLlnQ	-0.110	0.625	-2.451***	0.633	-0.035	0.377
lnPLlnFs	-0.515	0.617	0.201	0.739	-0.113	0.441
lnPwlnPs	-0.535*	0.320	1.591**	0.749	-0.343	0.272
lnPwlnK	0.044	0.074	-0.145**	0.075	-0.050	0.051
lnPwlnPQ	-0.029	0.214	15.918***	4.762	0.042	0.195
lnPwlnQ	0.068	0.097	0.259**	0.114	0.002	0.062
lnPwlnFs	-0.121	0.114	-0.171	0.170	-0.006	0.080
lnPslnK	1.218*	0.720	-0.004	1.150	0.486	0.558
lnPslnPQ	2.397	2.573	-12.873	15.676	2.339	1.839
lnPslnQ	0.892	0.930	-1.727	1.070	-0.209	0.685
lnPslnFs	-0.572	1.126	1.401	1.342	0.863	0.872

(Continued)

Table 5. (Continued)

Variables	Conventional groundnut seed producers		CGS producers		Pooled	
	Coefficient	Standard error.	Coefficient	Standard error.	Coefficient	Standard error
lnKlnPQ	-0.658	0.450	33.278***	8.921	-0.513	0.414
lnKlnQ	-0.052	0.192	0.111	0.224	0.107	0.130
lnKlnFs	0.069	0.188	-0.182	0.267	-0.091	0.146
lnPQlnQ	-1.272*	0.724	7.989	5.029	-0.367	0.572
lnPQlnFs	0.549	0.687	-126.519***	30.711	-0.137	0.648
lnQlnFs	0.814**	0.400	1.026***	0.353	1.328***	0.250
Constant	-0.149	0.124	-10.885**	4.478	-0.095	0.092
lnsig2v _cons	-1.961***	0.131	-2.353***	0.159	-1.781***	0.100
Sigma_v	0.375	0.025	0.308	0.025	0.410	0.021

No of observation = 119 84 205
Log likelihood = -55 - 23.82 - 109.64
Wald Chi-square = 1196.18 1459.5 1824.86
Prob.>Chi-square = 0.000 0.000 0.000

*, **, and *** are significant at 10%, 5%, and 1% respectively. ln = natural log, PQ = unit price of output (Gh¢), Q = quantity of output (kg), P_w = unit price of weedicide (Gh¢), P_L = wage of labour (Gh¢), P_S = price of seed (Gh¢), F_s = farm size (acres), K = capital (value of fixed input) (Gh¢).

influence profit level in CG production. This implies that increasing the price of these factors reduces the profit level in CG production. It was also found that price of output and quantity of output affect profit level positively. This implies that increasing the price of these factors increases the profit level in CG production.

From the results, there are significant input complementary effects between price of weedicide and price of seed and price of output and quantity of output in CG production. This implies that, when price of the pairs of factors is jointly increased, profit level will increase. Statistically, there are significant substitution effects on the profit level in CG production. The factors that are substitutes are wage of labour and capital, price of seed and capital, and quantity of output and farm size. This implies that, when the pairs of these factors are jointly increased, profit level will reduce.

The CGS producers' model also indicates that, while price of weedicide, wage of labour, and quantity of output were statistically significant at 5%, capital, price of output, and farm size were also statistically significant at 1%. The study noted that, apart from price of weedicide and capital which negatively influence profit level in CGS production, all the rest influence profit level positively. The inputs that established significant complementary effect in CGS production include wage of labour and price of seed, wage of labour and price of output, wage of labour and quantity of output, price of weedicide and capital, and price of output and farm size. This implies that, when price of the pairs of factors is jointly increased, profit level will increase. Statistically, there are significant substitution effects on the profit level in CGS production. The factors that exhibited substitution effects in CGS production include wage of labour and price of weedicide, wage of labour and capital, price of weedicide and price of seed, price of weedicide and price of output, price of weedicide and quantity of output, capital and price of output, and quantity of output and capital. This implies that, when price of the pairs of factors is jointly increased, profit level will reduce holding other factors constant.

From the metafrontier model, wage of labour and price of seed were statistically significant at 5%, whereas price of output, quantity of output, and farm size were statistically significant at 1%. The study revealed that wage of labour, price of seed, and farm size are negatively influenced by profit in the study area. It was also revealed that price of output and quantity of output affect the profit level

of groundnut seed producers negatively in the study area. From the results, there are significant input substitution effects between wage of labour and capital and quantity of output and farm size. This implies that, when price of the pairs of factors is jointly increased, profit level will reduce.

5.4. Determinants of profit inefficiency

Table 6 shows the results explaining the determinants of profit inefficiency. For CG producers, educational status, access to extension service, and access to mobile phone are significant determinants of profit inefficiency. Access to extension service and mobile phone is statistically significant at 10% and 5%, respectively. They negatively influence profit inefficiency of CG producers. This connotes that CG producers having access to extension service and mobile phone are more profit efficient than their counterparts. Contrary to a prior expectation, educational status was statistically significant at 5% and positively affect profit inefficiency in CG production. This implies that uneducated CG producers are more profit efficient than the educated.

For CGS producers, factors such as age, sex, marital status, years in education, number of extension visits, number of FBO meetings, and farming experience are significant determinants of profit inefficiency. Age is statistically significant at 5% and showed a positive relationship with profit inefficiency. This implies that a unit increase of CGS producers' age reduces their profit efficiency level. Sex of CGS producers was statistically significant at 5% and exhibited a negative relationship with profit inefficiency. This means that male CGS producers are more profit efficient than females. Wongnaa, Awunyo-Victor, and Mensah (2015) also found that males are more profit efficient than their counterparts among maize farmers in Ghana.

Marital status showed a direct relationship with profit inefficiency and was statistically significant at 5%, implying that unmarried CGS producers are more profit efficient than those married. The result conforms to Danso-Abbeam, Dahamani, and Bawa (2015), who also found farming experience, extension service, and education to affect profit inefficiency negatively, among smallholder groundnut farmers in the northern region of Ghana.

Again, CGS producers' years in education was significant at 10% and inversely affects profit inefficiency. More years in education increases profit efficiency in CGS production. The number of extension visits received by CGS producers was 5% statistically significant and negatively affects profit inefficiency. An increase in extension contacts results in an increase in profit efficiency level of CGS production. Also, the number of FBO meetings was statistically significant at 5% and exhibited a positive association with profit inefficiency in CGS production. This implies that increasing the number of FBO meetings in CGS production reduces profit efficiency. This result is contrary to Saysay, Gabagambi, and Mlay (2016) who found that FBO membership reduces profit inefficiency among smallholder rice farmers in central Liberia. Lastly, farming experience was statistically significant at 5% and negatively affects profit inefficiency in CGS production. As years of farming increases, profit efficiency of CGS producers also increases. In other words, groundnut farmers with more years of experience tend to operate at a significantly higher level of profit efficiency. The results are consistent with Sadiq and Singh (2015).

From the metafrontier profit model, age and access to mobile phone were statistically significant at 5% and negatively affect profit inefficiency in groundnut seed production. This implies that profit efficiency increases as the age of groundnut seed producers increases. Also, groundnut seed producers having access to mobile phone increases their profit efficiency level more than their counterparts.

5.5. Distribution of profit efficiencies

Table 7 is a frequency distribution table showing the profit efficiency scores of CGS and CG producers. The CGS producers displayed a wide range of profit efficiency ranging from 15% to 87%, whilst CG producers recorded a profit efficiency range of 11–85%. The results indicated that 4% of the CGS producers are close to the profit efficiency frontier, whereas about 2.0% are far from the profit efficiency frontier. Conversely, the majority (6.7%) of CG farmers are far from the profit

Table 6. Determinants of profit inefficiency in groundnut seed production

Variables	Conventional groundnut seed producers		CGS producers		Pooled	
	Coefficient	Standard error.	Coefficient	Standard error	Coefficient	Standard error
Age	-0.623	0.383	0.985**	0.436	-0.640**	0.306
Sex	-1.870	2.924	-17.346**	7.870	-2.540	1.947
Marital status	-0.328	2.236	30.218**	15.372	0.812	1.932
Household size	0.008	0.301	0.049	0.297	-0.022	0.272
Educational status (dummy)	3.950**	1.918	NA	NA	2.162	1.738
Years in education	NA	NA	-2.933*	1.652	NA	NA
Access to extension (dummy)	-5.147*	3.001	NA	NA	-5.598	4.639
Number of extension visit	NA	NA	-5.171**	2.281	NA	NA
Number of FBO meetings	NA	NA	3.493**	1.705	NA	NA
Access to mobile phone	-8.735**	4.617	-6.745	5.843	-7.506**	3.609
Farming experience	-0.051	0.176	-1.650**	0.735	-0.105	0.109
Constant	19.245	14.793	-37.024**	16.702	20.035**	10.499

* and ** are significant at 10% and 5% respectively. NA represents not applicable.

Table 7. Frequency distribution of profit efficiencies

Efficiency range	CGS producers		Conventional groundnut seed producers	
	Frequency	Percentage	Frequency	Percentage
0.10-0.20	2	2.00	10	6.67
0.21-0.30	4	4.00	7	4.67
0.31-0.40	6	6.00	15	10.00
0.41-0.50	12	12.00	23	15.33
0.51-0.60	21	21.00	37	24.67
0.61-0.70	22	22.00	35	23.33
0.71-0.80	29	29.00	22	14.67
0.81-0.99	4	4.00	1	0.67
Total	100	100	150	100
Minimum =	0.1529		0.1086	
Maximum =	0.8722		0.8537	
Mean =	0.5811		0.5354	
Standard deviation =	0.1577		0.1688	

Source: Field survey (2018).

efficient frontier, whilst 0.7% are close to the profit frontier. The study observed that even the most efficient CGS producer and CG producer were not optimal in the allocation of resource and need improvement to attain a frontier profit.

The mean profit efficiency scores of CGS producers and CG producers are 0.58 and 0.54, respectively. This implies that CGS producers achieved on average 58.0% level of profit, whilst CG producers achieved 54.0%. This indicates that about 41.9% of the profit obtained by CGS producers is lost as compared with CG producers who lose 46.5% of the profit due to inefficiencies of the farmers. Hence, an average of 41.9% and 46.5% of the profit efficiency is required by CGS and CG producers to attain frontier profit, respectively. Sadiq and Singh (2015) obtained a minimum of 12% and a maximum of 95% (with a mean of 71%) for maize farmers in Niger State, Nigeria. Galawat and Yabe (2012) reported a minimum of 45.2% and a maximum of 99.2% (with a mean of 81%) for rice farmers in Brunei Darussalam. Bocher and Simtowe (2017) also found profit efficiency ranged from 1% to 89% (with a mean of 45%) among groundnut farmers in Malawi. This study conforms to the aforementioned results of the above researchers.

Table 8 shows Welch's t-test for profit efficiency between CGS and CG producers. The results noted that there is a statistical difference in profit efficiency level between CGS and CG producers. From the table, CGS producers recorded an average profit efficiency score of 4.67% more than their counterparts. This means that CGS producers are 5.0% more profit efficient than CG producers. This result is consistent with

Table 8. Welch's t-test for profit efficiency between CGS and CG producers

Profit efficiency	Observation	Mean	Standard error
CG producers	150	0.5299	0.0170
CGS producers	100	0.5776	0.0166
Total	250	0.5486	0.0123
Difference = -0.0467 0.0249t-Value = -1.8788 p-Value (T<t) = 0.0307			

Source: Field survey (2018).

Onumah et al. (2016) where the organic systems exhibit an increasing return to scale, whilst the conventional system exhibits decreasing returns to scale.

6. Conclusions and recommendations

Based on the results obtained from the study, it can be concluded that CGS production is more profitable than CG production in Northern Ghana. This is attested by the fact that CGS producers obtained significantly higher profit and BCR than CG producers. Again, CGS producers are 5% more profit efficient than CG producers. The factors that affect profit level and profit efficiency in CG production include price of labour, price of seed, quantity of output, price of output, and farm size and educational status, access to extension, and access to mobile phone, respectively. The profit efficiency of CGS producers is influenced by age, years in education, number of extension visits, number of FBO meetings, and farming experience, whereas price of weedicide, price of labour, capital, quantity of output, price of output, and farm size affect their profit level. It is, therefore, recommended that extension agents should establish FBOs to enable them train and encourage farmers to use CGS in production to increase yields. Credit packages should be made available to CGS producers to enable them upscale production to bridge the demand deficit in the country. Government policy in the form of crop subsidy implementation on groundnut seed production will attract more private investors.

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