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Economic analysis of two cabbage cultivars produced at different levels of applied water

E. Kondo [1*], D.K. Asare [1], I.T. Larteh [1], J.O. Frimpong [1], K.E. Banson [1], E.O. Ayeh [1], L.K. Heng [2]

[1] *Biotechnology and Nuclear Agriculture Research Institute, BNARI- GAEC, Box L G 80, Legon, Ghana*
[2] *Water Management and Crop Nutrition Section, IAEA, Vienna, Austria*

Abstract

This paper examines the economic analysis of the production of two cabbage varieties, KK-Cross and Oxylus, grown under water application levels of 100%, 85%, 70%, 55% and 40% of the required water using a small-scale drip-irrigation system. Marketable yield data for drip-irrigated KK-Cross and Oxylus were obtained from on-station field experiments, farm gate price of cabbage was obtained from farmers whilst input cost associated with the installation of small-scale drip-irrigation system were estimated. Analyses showed that the KK-Cross cabbage variety has higher Net Present Values (NPVs) than Oxylus at all the different water application levels except at the 55%. The Benefit-Cost-Ratios (BCRs) were also lower for Oxylus than KK-Cross thereby making the production of KK-Cross economically viable. Results further indicate that the mean paired comparison t-test of the cumulative BCRs were statistically different ($P \leq 0.05$). However, paired comparison t-test analysis showed no significant difference ($P > 0.05$) between NPVs of KK-Cross and Oxylus production. Farmers are therefore likely to reap higher economic returns from the cultivation of KK-Cross than Oxylus. It is however recommended that production of KK-Cross and Oxylus should not be done at 40% level of applied water as BCR values at that water application level were close to 1.0.

Keywords: Brassica oleracea; drip –irrigation; net present value; benefit-cost-ratio; KK-Cross; Oxylus; mean comparison paired t-test

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* Corresponding author. *E-mail address:* kondoebenezer@gmail.com

1. Introduction

Cabbage (*Brassica oleracea* L. var. *capitata*) is a vegetable crop grown worldwide including African countries (FAO/WHO, 1995). In Ghana, cabbage production is mostly popular among peri-urban and urban dwellers in response to high demand (Timbilla and Nyarko, 2004). It is known that cabbage production serves as an important source of employment for small-scale vegetable farmers, contributing towards households' food and nutrition security and income generation leading to poverty reduction.

Cabbage has been classified as moderately susceptible to water stress, with the head formation period being more sensitive (Bruce et al., 1980; Nortje and Henrico, 1988; Duncan et al., 1990). Doyle et al. (1994) and Janes (1950), have all reported on the impact of different irrigation regimes on the productive yield of cabbage. Cabbage production, therefore, requires sufficient supply of water and good water management practices for high yield and good quality produce.

Though the production of cabbage in the coastal savannah environment of Ghana is lucrative during the dry season (November to February), inadequate available water limits production (Larteh, 2011). Drip-irrigation, being the most effective and efficient way of delivering water and nutrients directly to the root zone of crops (Tiwari et al., 2003), ensures 30% to 70% reduction in the use of applied water while increasing yield over 50% (Salim-Ali et al., 2004). Consequently, the small-scale drip system can be a suitable option for cabbage production in environments characterised by water scarcity such as the coastal savannah environment of Ghana.

For vegetable farmers to adopt the small-scale drip-irrigation technology to produce cabbage under inadequate water conditions there is the need to ascertain its economic viability, especially in relation to different levels of applied water. This study, therefore, analyses the economic viability of two cabbage cultivars, KK-Cross and Oxylus, produced using a small-scale drip-irrigation system at five different levels of applied water during the dry season in a coastal savannah environment of Ghana. Paired comparison t-test analysis was also used to determine which of the two cabbage cultivars yielded the higher economic returns on investment at the different levels of applied water. Results of this study are expected to inform decision as to how low to reduce the optimally required level of seasonal water so as to obtain good economic returns in cabbage production in an environment characterized by water scarcity.

2. Materials and methods

2.1. Data used for the study

Marketable yields of two cabbage cultivars, KK-Cross and Oxylus obtained from an on-station research field, fixed and variable cost of production inputs per annum discounted for a period of five years, prevailing farm gate price of cabbage obtained through interview with farmers and market survey were used for the study. Data on marketable yields were from a well replicated and randomized field experiment conducted between November 2010 and January 2011, during the dry season at Atomic-Kwabenya situated in the coastal savannah environment of Ghana. The two cabbage cultivars were grown using a small-scale drip-irrigation system under five different water application levels. The irrigation levels were 40, 55, 70, 85 and 100% of the optimum required water levels which corresponded to 107.3, 145.5, 184.1, 222.5 and 260.9 mm of applied water, respectively, for the entire growing season (Larteh, 2011). Analyzed discounted cash flow figures for marketable yields, fixed and variable costs of production of the two cabbage cultivars as well as farmgate prices are summarized in Table 1.

Table 1. Summarized discounted cash flow analysis for KK Cross and Oxylus at the different water application levels for a five year-period

	KK Cross			**Oxylus**		
Level of applied water	**NPV@30% (GHS)**	**Discounted cost (GHS)**	**Discounted benefit (GHS)**	**NPV@30% (GHS)**	**Discounted cost (GHS)**	**Discounted benefit (GHS)**
100%	54,285.69	15,538.80	70,653.01	32,103.60	15,538.80	47,104.40
85%	31,863.09	14,293.20	46,158.21	20,921.34	14,293.20	35,214.54
70%	14,966.67	13,658.80	28,625.75	7,578.94	13,658.80	21,237.74
55%	7,673.00	13,574.60	21,247.59	14,234.56	13,574.60	23,681.27
40%	3,856.68	12,414.40	16,273.17	1,575.00	12,414.40	13,989.40

2.2. Economic analysis

Two economic parameters, Net Present Value (NPV) and Benefit-Cost-Ratio (BCR) were used to analyse the economic returns associated with KK-Cross and Oxylus production under different levels of applied water using the small-scale drip-irrigation system.

2.3. Net Present Value analysis

Gittinger, (1982) provided the theoretical framework for NPV analysis stating that the NPV of an enterprise is the present worth of the net incremental benefit or incremental cash flow stream. The incremental net benefit is the increase in net benefit with the project as against without the project. The NPV then simply describes the present worth of the income stream from an investment. In NPV analysis, a discount rate is required which is usually the opportunity cost of capital (Yeboah, 2009). This is the rate that results after the utilization of all capital in the economy if all possible investments undertaken in the economy generate that much or more. In other words the opportunity cost of capital is the return on the last or marginal investment made that exhausts the last available capital. This opportunity cost of capital is usually assumed to be equivalent to lending rates of commercial banks within the project's locality (Gittinger, 1982).

Mathematically, the NPV is expressed as:

$$\text{NPV}= \sum_{t=1}^{n} \frac{(Bt-Ct)}{(1+\mathrm{r})^{\mathrm{t}}}$$

Adapted from [Gittinger, 1982]

where, B_t is the benefit in each project year, C_t is the cost in each project year, n is the number of years, t is the year and r is the discount (interest) rate. That is, the NPV is computed by subtracting the total discounted present worth of the cost stream from the discounted present worth of the benefits. All analyzed projects with NPV of zero or greater is accepted while analysed projects with negative NPV is rejected since the projects would not be able to recover its investments (Gittinger, 1982).

2.4. Benefit-Cost-Ratio analysis

Benefit–Cost-Ratio (BCR) is the ratio obtained when the present worth of the discounted benefit stream is divided by the present worth of the discounted cost stream. As in the case of the NPV, an appropriate opportunity cost of capital is required for BCR computation (Gittinger, 1982).

Mathematically, BCR is expressed as:

$$\mathrm{BCR} = \frac{\sum_{\mathrm{t}=1}^{\mathrm{n}} \frac{\mathrm{B_t}}{(1+\mathrm{r})^{\mathrm{t}}}}{\sum_{\mathrm{t}=1}^{\mathrm{n}} \frac{\mathrm{C_t}}{(1+\mathrm{r})^{\mathrm{t}}}}$$

Adapted from [Gittinger, 1982]

where B_t is the benefit in each project year, C_t is the **c**ost in each project year, n is the number of years, t is year and r is the discount (interest) rate. The selection criterion is to accept all analysed projects with BCR value of at least 1.0 after discounting benefits and costs at the selected opportunity cost of capital (Gittinger, 1982). An opportunity cost of capital of 30% was selected for the study as this was the prevailing interest rate for most commercial banks.

2.5. Assumption(s)

The major assumption underlying the analysis is the use of the prevailing market interest rate as the discount factor which is found to be 30% for most financial institutions. The drawback for using this opportunity cost of capital is that it is usually unknown and as such the lending rates of commercial banks within the projects locality are usually adopted (Gittinger, 1982).

2.6. Paired comparison t-test analysis

The mean paired comparison t-test was used to test for similarities and differences in both NPV and BCR values for KK-Cross and Oxylus. The STATA statistical software (S.E 9) was used for the paired comparison t-test analysis.

3. Results and discussion

Expected returns on the production of KK-Cross and Oxylus differed across the levels of applied water. Generally, the cabbage cultivar KK-Cross had comparatively higher returns at each of the levels of applied water, except at 55% of the required level of applied water where returns for Oxylus was higher (Figure 1).

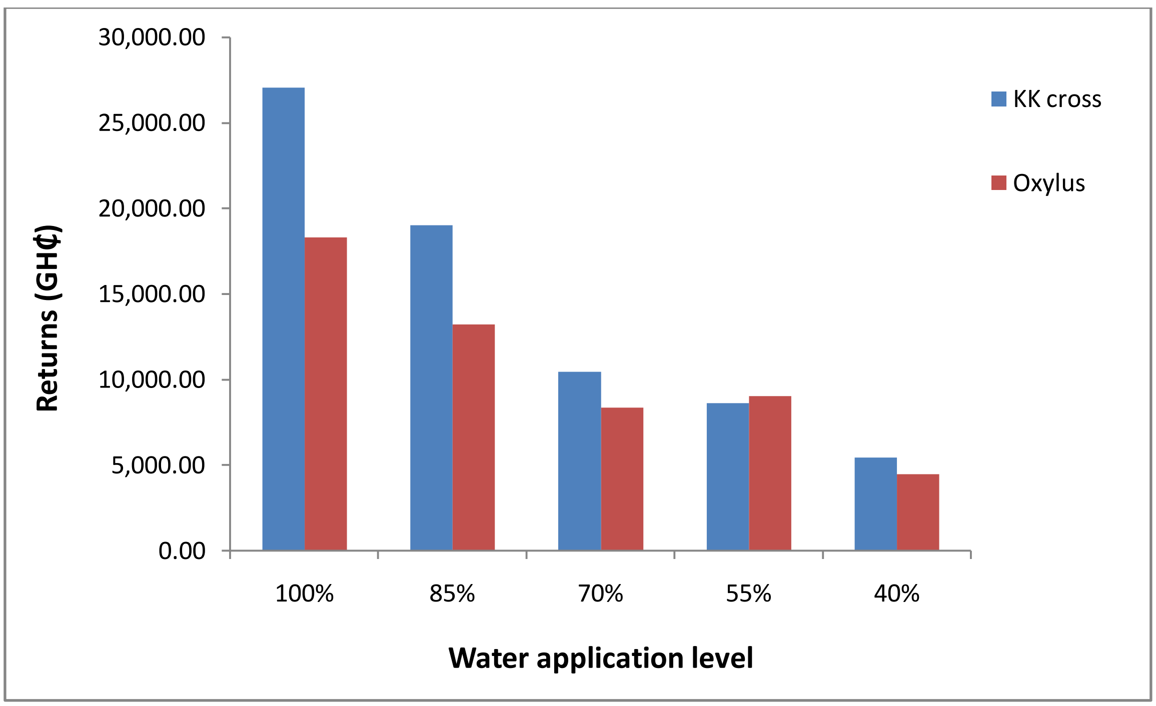

Figure 1. Expected returns from cabbage production at different water application levels

The discounted cash flow analysis for KK-Cross and Oxylus for the different water application levels with their corresponding NPV, discounted cost and discounted benefits over a five-year period are presented in Table 1. The discounted cash flow analysis at 100% water application level for both KK-Cross and Oxylus for their NPVs are respectively GH₵54,285.69 and GH₵32,103.60, indicating that more returns on investment was obtained from the production of KK-Cross than Oxylus over a five-year period of production. The Benefit Cost Ratios (BCRs) of 4.54 for KK-Cross and 3.0 for Oxylus also proved that the production of KK-Cross at the 100% water application level is more profitable. The comparatively higher returns from the KK-Cross production compared to returns from Oxylus production were as a result of higher marketable yield of KK-Cross observed under the 100% level of applied water. This finding is contrary to results reported by Osei et al. (2013), that farmers in the Brong Ahafo Region of Ghana preferred Oxylus to KK-cross because of better yield and returns.

Table 2. Benefit Cost Ratios (BCRs) for KK-Cross and Oxylus at different levels of applied water for a five-year period.

Level of Applied Water	KK-Cross	Oxylus
100%	4.5	3.0
85%	3.2	2.5
70%	2.1	1.7
55%	1.6	1.7
40%	1.3	1.1

Table 3. Mean comparison paired t-test analysis of Net Present Value and Benefit Cost Ratio of KK-Cross and Oxylus production

Variable	t-test	P-value [Pr(|T| > |t|)]
NPV	1.53	0.202
BCR	2.06	0.108

Economic analysis for the lower than 100% water application levels showed that economic returns were lower than that observed for 100% water application level for both cabbage cultivars. However, returns reduced as the level of applied water reduced from 100%, with KK-cross production generally yielding higher economic returns than Oxylus (Tables 1 and 2). However, economic returns on Oxylus production at

55% water application level were higher than those of KK-Cross (Tables 1 and 2). It is, therefore, generally more profitable to produce KK-Cross than Oxylus at reduced level of applied water. Additionally, the BCR values for KK Cross production were higher than those of Oxylus (Table 2), indicating that the production of KK Cross is more profitable than that of Oxylus.

The BCR values decreased with increasing number of years that the cabbage production was undertaken as a result of increasing outlay in production over the years. This notwithstanding the production of the two cabbage cultivars still remained economically viable as the BCR value exceeds unity in all cases (Table 2). It became evident from the result obtained that economic viability was still achieved even when the level of applied water was 40%, with BCR of KK-Cross being higher than that of Oxylus but very close to the value of 1.0 (Table 2).

Furthermore, paired comparison t-test analysis showed that NPV and BCR values over a 5-year production of KK-Cross and Oxylus were statistically different ($P \leq 0.05$), with NPV for KK-Cross being higher than that for Oxylus (Table 3). These suggest that KK-Cross production generally resulted in statistically higher economic returns than Oxylus.

The discounted cash flow analyses performed over a 5-year period for the two cabbage cultivars, KK-Cross and Oxylus, at different water application levels showed higher benefits, Net Present Values and Benefit-Cost-Ratios for all the cabbage cultivars, with KK-Cross generally showing higher economic returns. Paired comparison t-test analysis on the benefit- cost-ratios (BCRs) also showed that significant difference ($P \leq 0.05$) existed in the cumulative BCR values for KK-Cross and Oxylus, suggesting that other biotic factors are likely to influence yield and subsequently economic returns. However, no significant difference was observed in the NPVs of KK-Cross and Oxylus even though NPVs for KK-Cross were generally higher.

4. Conclusion

Based on the results obtained for the Net Present Values and Benefit Cost Ratios, as well as the mean comparison result, farmers therefore stand a chance of reaping better economic returns in the production of the cabbage cultivar KK-Cross than Oxylus. The result from the study also reveals that economic returns for the production of the cabbage cultivars increased with increasing levels of applied water. As BCR values for the production of KK-Cross and Oxylus were close to the value 1.0 under the 40% water application level (60% reduction in the required level of water), it is therefore recommended that farmers may have to weigh the option of producing cabbage cultivars, KK-Cross and Oxylus, at such a low water application level in order to avoid low economic returns or loss.

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