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A cost-benefit analysis for utilization of poultry manure in cabbage production among smallholder crop-livestock farmers

Mugerwa Swidiq[1*], Kabirizi Jolly Mary[1], Kigongo John[1], Zziwa Emmanuel[2]

[1]*National Livestock Resources Research Institute, P.O. Box 96, Tororo, Uganda*

[2]*Department of Agricultural Production, Makerere University, Uganda*

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Abstract

Efficient utilization of animal manures is critical in sustaining productivity and profitability of smallholder crop-livestock production systems. However, adoption of particular manure application regimes would only be possible if the recommended regimes make economic sense to farmers whose major objective is usually to generate incomes. An on-farm experiment was conducted for three rainy seasons in Uganda to evaluate the economic benefits derived from production of cabbage under different levels of poultry manure (PM). The PM levels investigated included 0t/ha^{-1}, 1t/ha^{-1}, 2t/ha^{-1}, 3t/ha^{-1}, and 4t/ha^{-1} replicated three times per season. The total costs that vary, the gross and net benefits for each treatment were calculated and subsequently used to construct a partial budget from which dominance analysis was conducted. The non dominated treatments were then selected for marginal rate of analysis. The highest net benefits (Ug. shs 9,266,000) were obtained at 4t/ha. The net benefits at 4 and 3 t/ha were 21 and 13% higher than the benefits at 0 t/ha. Dominance analysis indicated that the net benefits of treatments 1 and 2 t/ha was lower than the net benefits of treatment 0 t/ha. The marginal rate of return (MRR) from 0 to 3 was 189%. Increasing the rate of PM from 3 to 4 t/ha resulted into a MRR of 237% while increasing the rate from 0 directly to 4 t/ha showed a much higher MRR of 384%. The results of study revealed that cabbage production was most profitable at 4t/ha of PM application.

*Corresponding Author: Mugerwa Swidiq ✉ swidiqk@yahoo.com

Introduction

Cabbage (*Brassica oleraceae* L.) belongs to the Brassicaceae family and is a cool season crop (Best, 2000). It contains 93 ml water, 1.5 g protein, 0.2 g fat, 4 g carbohydrate, 40 mg calcium and 0.5 g iron/100 g sample (Moamogwe, 1995). Cabbage is one of the priority vegetable crops cultivated in smallholder crop-livestock systems in Central Uganda in an attempt to diversify income generating sources as well as to enhance nutrition of smallholder farmers. The farmers use varying levels of poultry manure to optimize yields of both cabbage heads and non-wrapped leaves which subsequently constitute an important source of feed to poultry (layer birds) and livestock (especially pigs). Poultry manure is an important source of plant nutrients with an average content of 3.03 % N, 2.63 % P_2O_5 and 1.4 % K_2O (Reddy and Reddi, 1995). Sunassee (2001) reported that 30 % of nitrogen from poultry litter is in urea or ammonium form and is hence readily available to plants. In addition to releasing nutrients, it also improves the physical properties of soil.

Yield response of leafy vegetable crops such as lettuce and cabbage to different levels of poultry manure application has been demonstrated by Cesalis (2002) and Ijoyah & Sophie (2009) respectively. Several studies (Talekar, 2000; Ijoyah & Sophie, 2009) have reported that the amount of PM required for optimum yield of cabbage and non-wrapped leaves ranged between 20 to 30 t/ha. However, the limited availability of adequate quantities of PM in smallholder crop-livestock farmers attributed to dairy based integrated farming systems in Central Uganda, impede utilization of PM beyond 5 t/ha. Majority of the farmers therefore apply PM at lower rates ranging from 0 to 4 t/ha but the yield responses to such low levels of PM application has not been investigated. Further, whether the currently used PM rates produce significant positive responses in cabbage yield or not, the rates need to make economic sense to farmers whose major objective is to generate incomes. Kishor (2011) emphasized the importance to undertake economic analyses for various agricultural technologies to save farmers' meager resources to enhance competitiveness of agricultural activities. It is therefore necessary for farmers to know how much additional income can be generated by investing more resources into a given technology. The objective of the study was to evaluate the economic performance of cabbage produced under different rates of PM application in smallholder crop-livestock systems.

Materials and methods

Study site

The experiment was conducted at Kamenyamiggo District Agricultural Training and Information Centre (DATIC) located in Central Uganda. The rainfall pattern is bimodal having two seasons with dry spells between July and August, and December to February. The months of March, April and May receive very heavy and well-distributed rains of up to 1,200 mm. The second season occurs in the months of September to November. With the exception of a few years of declining trend in precipitation, the annual average rainfall received is between 1100 mm–1200 mm with 100–110 rainy days. Temperatures range between 10°C to 30°C with almost equal length of day and night throughout the year. The humidity level is generally low throughout the region with the exception of lakeshore areas where it tends to rise.

Experimental design, data collection and analysis

Decomposed poultry manure constituted the treatment at five levels: 0, 1, 2, 3 and 4t/ha. The five levels were randomly allocated to 15 plots (4 x 4 m each) following a randomized complete block design with three replications. The PM rates were broadcasted and incorporated into the soil at the onset of rains. Six rows were made in each plot and cabbage seedlings (Glory variety) were spaced at 50 cm x 45 cm. Each row consisted of 9 plants giving a total population of 54 plants per plot. Data was collected on number of heads per plot, head weight per plant, total head weight (cabbage yield) and weight of un-wrapped leaves. The data was subjected to Analysis of Variance for a Randomized Complete Block Design (RCBD) using XLSTAT (2011).

Economic analysis

Estimation of costs that vary

The costs that varied with treatments included costs incurred (per hectare) in purchase, transportation and application of different quantities of poultry manure. The cost incurred in transportation of manures to farmers' farms was factored into the overall cost incurred to purchase PM. Consequently, the costs that varied for the different levels of PM were of two types: 1. costs incurred (per hectare) in purchase of PM and (2). Costs incurred for labor during application of PM. The total costs that vary for each treatment were then calculated by summing the two types of cost as described by (CIMMYT, 1989). The average cost of a 70kg bag of PM was Uganda shillings (Ug. shs) 7,000 and the average transportation cost of each 70kg bag to farmers' fields was Ug. shs 3000. Hence the cost of purchasing and transporting a 70kg bag was Ug. Shs 10,000. The cost incurred to purchase and transport 1kg of PM was therefore computed as 10,000/70= Ug. shs 143. We therefore multiplied Ug. shs 143 by the total amount of PM/ha to obtain the cost incurred in purchase and transportation. Also, the average cost incurred in the application and incorporation of 70kg bag of PM in the soil was Ug. shs 2000 resulting into a labor cost of Ug. shs 28.6 per kg of PM. The total cost incurred in application of PM was therefore obtained by multiplying 28.6 by the total amount of PM per hectare. The two costs were then summed up to obtain the total costs that vary per treatment as demonstrated in the results section.

Estimation of gross field and net benefits

Assessment of cabbage yields on farmers' farms within the area revealed that farmers' yields were 20% lower than the yields obtained on experimental sites. We therefore adjusted the yield achieved in the experiment by reducing it by 20% to represent actual yield scenarios. The average cost of 1kg of cabbage (head) was estimated at Ug. shs 250 and this was multiplied by the adjusted cabbage yield to obtain the gross field benefits from cabbage sales. Further, the average cost of 1kg of un-wrapped leaves (fodder) was estimated at Ug. shs 5 which was multiplied by the adjusted yield of un-wrapped leaves to obtain the gross field benefits associated with un-wrapped leaves. The two figures were summed up to obtain the total gross field benefits. The total costs that vary per treatment were subtracted from the total gross field benefits to obtain the net benefits per treatment.

Results

Yield of cabbage heads and non-wrapped leaves

All the four levels of PM gave increased head weight per plant than the 0 t/ha PM but the increments were not significant (Table I). PM rate of 3 t/ha gave the highest mean head weight (2.66 kg) followed by PM rate of 4 t/ha which had a mean head weight of 2.45 kg. PM rate of 3 and 4 t/ha increased the head weight by 24 and 14%, respectively. PM rate of 4 t/ha gave the highest weight of non-wrapped leaves (171,500 kg/ha) and a yield of 46,331 kg/ha. The weight of non-wrapped leaves and cabbage yield obtained at PM rate of 4 t/ha was 21 and 31% respectively higher than that obtained at PM rate of 0 t/ha but the increments were also non- significant. Increasing PM rate from 0 to 1 t/ha resulted in to a decline in yield of 35% while a very small increment (2%) was noted by increasing PM rate from 0 to 2 t/ha.

Economic analysis

The highest net benefits of Ug. shs 9,266,000 and Ug. shs 8,607,200 were obtained at 4 and 3 t/ha respectively (Table II). The net benefits at 4 and 3 t/ha were 21 and 13% higher than the benefits (Ug. shs 7,632, 848) at 0 t/ha. Dominance analysis (Fig. I) indicated that the net benefits of treatments 1 (5,495,312) and 2 t/ha (7,235,724) were lower than the net benefit of treatment 0 t/ha implying that the two treatments were dominated. Increasing the rate of PM application from 0 to 1 t/ha lead to a 35% decline in cabbage yields and an increment variable costs. Consequently, the net benefits at 0 t/ha were more than those at 1 t/ha. Also, the yield at PM rate of 2 t/ha was just 2% higher than that at 0 t/ha yet a lot of costs (Ug. shs 343,200) were incurred in purchase and application of PM.

Table 1. Effect of different PM rates on yield of cabbage and non-wrapped leaves.

Treatments (tones/ha)	No. of heads/ha	Mean head weight (kg)	Cabbage yield (kg/ha)	Weight of non-wrapped leaves (kg/ha)
0	63125[a]	2.15[a]	35328[a]	141812.5[a]
1	48125[a]	2.16[a]	26257.8[a]	103828[a]
2	47500[a]	2.16[a]	35993.8[a]	95031[a]
3	57500[a]	2.66[a]	42500[a]	153500[a]
4	70000[a]	2.45[a]	46331.3[a]	171500[a]

[a]Means with the same superscripts are not significantly different at p=0.05.

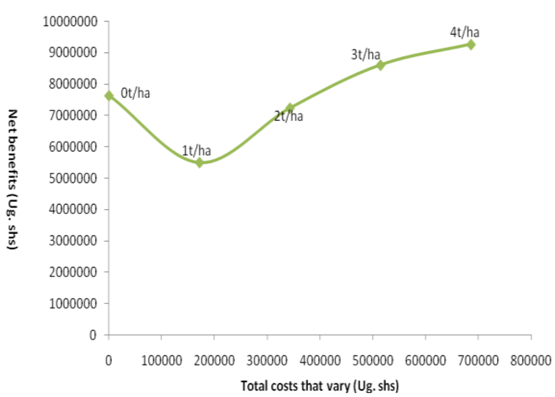

Fig. 1. Net-benefit curve for different PM rates.

Raising the rate of PM from 0 to 2 t/ha led to a decline in the net benefits, however, beyond 2 t/ha, further increment in the amount of PM amended to the soil resulted in an increase in net benefits. The marginal rate of return (MRR) from 0 to 3 was 189%. Increasing the rate of PM from 3 to 4 t/ha resulted into an MRR of 237% while increasing the rate from 0 directly to 4 t/ha showed a much higher MRR of 384%.

Discussion

Yield of cabbage heads and non-wrapped leaves

The positive correlation between levels of PM with cabbage yield and head weight per plant was attributed to the improved soil physico-chemical properties and hence improved establishment and growth of the plant. This positive relationship has also been reported by Talekar (2000) and Rajkomar (2002). The mean head weight per plant (2.3 kg) obtained in the study was higher than that reported in other studies and this was partly attributed to varietal response to different environments (Ijoyah and Sophie, 2009). The lack of significant differences among values for head weight per plant, weight of non-wrapped leaves and cabbage yield was possibly due to the low rates of PM investigated in the current study. In this regard, Ijoyah and Sophie (2009) also reported that significant differences could only be obtained at PM ≥ 10t/ha. The reduction in cabbage yield at PM rate of 1 t/ha could be attributed to the fact that addition of manure with high C:N ratio stimulates the activities of soil microorganisms leading to immobilization of nitrogen and making it unavailable to plants and consequently causing a decline in plant growth (Brady, 1990).

Economic analysis

The decline in yield as PM was increased from 0 to 1 t/ha and the small increment (2%) in yield by increasing PM rate from 0 to 2 t/ha were responsible for the dominance and thus non-profitability of the two treatments (1 and 2 t/ha). The decline and the small increment in yield at treatments 1 and 2 t/ha could therefore not justify the costs incurred. CIMMYT (1989) noted that the minimum marginal rate of return acceptable to farmers before making a decision to change from an old practice to a new practice is 50%. In this study, the MRR from 0 to 3 and from 3 to 4 t/ha were 189 and 237% respectively, far beyond 50%. This implied that when a farmer invested one shilling as an additional cost to change from 0 to 3 t/ha, the farmer would recover the one shilling and an additional 1.89 shillings as profit. Likewise, when a farmer invested a shilling as an additional cost to change from 3 to 4 t/ha, the same farmer would recover a much more profit of 2.37 shillings in addition to recovering the invested one shilling. This is to say, when a farmer invested Ug. shs 171,600 more to move from 3 to 4 t/ha, the farmer would obtain Ug. shs 324,324 (171,600 * 1.89) as profit in addition to recovering the invested Ug. shs 171,600.

Table 2. Partial budget and dominance analysis of different PM rates.

	Treatments (t/ha)				
	0	1	2	3	4
Average fodder yield (kg/ha)	141812	103828	95031	155500	171550
Average cabbage yield (kg/ha)	35328	26258	35994	42500	46331
Adjusted yield, fodder (kg/ha)	113449.6	83062.4	76024.8	124400	137240
Adjusted yield, cabbage (kg/ha)	28262.4	21006.4	28795.2	34000	37064.8
Gross field benefits, fodder	567248	415312	380124	622000	686200
Gross field benefits, cabbage	7065600	5251600	7198800	8500000	9266200
Total gross field benefits	7632848	5666912	7578924	9122000	9952400
Cost of poultry manure	0	143,000	286000	429,000	572,000
Cost of labour to apply manure	0	28600	57200	85800	114400
Total cost that vary (Ug. shs/ha)	0	171600	343200	514800	686400
Net benefits (Ug. shs /ha)	7632848	5495312	7235724	8607200	9266000
Dominance analysis	7632848	5495312D	7235724D	8607200	9266000

[D] Dominated treatment, 1 US$=2800 Uganda shillings

Conclusion

From the results obtained, it can be concluded that the application of 4 t/ha of decomposed poultry manure is recommended among the smallholder crop-livestock farmers in Central Uganda. This application rate was associated with higher weight of non-wrapper leaves, head weight per plant, yield, net benefits and Marginal rate of return. Application of PM at 1 and 2 t/ha as practiced by many farmers is not profitable as it results into lower net benefits achieved with higher variable costs as compared to PM at 0 t/ha.

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