Farmer participatory evaluation of the potential for organic vegetable production in the wetlands of Zambia

E. Kuntashula, G. Sileshi, P.L. Mafongoya and J. Banda

***Abstract**: Although wetlands (locally called dambos) are considered extremely vulnerable to poor agricultural practices, rising population pressures have caused their agricultural use to become increasingly important. Intensification of dambo use by way of chemical fertilizer and pesticide applications poses serious challenges to their ecological sustainability. This study evaluated gliricidia (Gliricidia sepium) leafy biomass as a possible alternative to commercial fertilizer, and Tephrosia (Tephrosia vogelii) leaf extract, commercial formulations of neem seed extract (Achook) and Bacillus thuringiensis (Thuricide) as alternatives to chemical pesticides in the production of cabbage in dambos. The study showed that soil fertility management practices can significantly influence the time to harvest the cabbage crop and its yield. Vegetables grown using gliricidia biomass produced significantly higher yields compared with the no-input option. The population density of diamondback moth (Plutella xylostella) larvae, the percentage of plants infested by cabbage webworm (Hellula undalis) and cabbage aphid (Brevocoryne brassicae) was significantly lower in cabbage treated with sprays of Tephrosia leaf extract and Achook. It is concluded that gliricidia leafy biomass as a soil fertility management practice combined with Tephrosia leaf extract and neem seed extract as a crop protection practice could increase the productivity of cabbage and ensure sustainable utilization of dambos.*

***Keywords:** dambos; legume biomass; biopesticides; sustainability*

E. Kuntashula is with the Department of Agricultural Economics and Extension, University of Zambia, PO Box 32379, Lusaka, Zambia. E-mail: Kelias@mailcity.com. G. Sileshi, P.L. Mafongoya and J. Banda are with the Zambia-ICRAF Agroforestry Project, PO Box 510089, Chipata, Zambia.

Recurrent droughts, increasing production costs caused by the removal of subsidies on agricultural inputs, and falling output prices have contributed to rural poverty and hunger in southern Africa. Due to the increasing pressure on land for food, fodder, fibre and fuelwood production, agricultural practices and policies have recently tended to favour intensification through increased areas of irrigation and external inputs. While this is welcome, there is an equal need to focus on sustainability, so that intensive agricultural activities do not conflict with environmental quality, especially chemical pollution, affecting biodiversity, soil and water quality, and the health of consumers of these products. Improvement of agricultural practices and diversifying sources of farm income are regarded as important steps towards poverty alleviation and enhancing the quality of life of smallholder farmers and their environment. A good example of agricultural intensification that requires serious consideration is vegetable production in the wetlands (locally known as *dambos*) in southern Africa.

Broadly speaking, a *dambo* can be defined as a wide and low-lying, gently sloping, treeless, grass-covered depression, which is seasonally waterlogged by seepage from surrounding high ground, assisted by rainfall, and which has a water table that for most of the year is in the upper 50–100 cm of the soil profile, from which it drains into streams (Breen *et al*, 1997). Scattered throughout the southern African region, over 16 million hectares of land is covered by *dambos*. In Zambia alone, the area is over 3.6 million hectares of land – 4.6% of the country's area (Ferreira, 1981).

Several studies (Perera, 1982; Bell *et al*, 1987; Kundhlande *et al*, 1995) have established that *dambos* are strategic resources worth exploiting for food production to cope with hunger that is manifested particularly during drought years. The utilization of *dambos* during both the dry and rainy seasons adds diversity and increases the possibility of supporting different livelihoods and combinations of livelihoods. This diversity is expressed spatially through activities taking place in different parts of the landscape, temporally (both seasonally and inter-annually) and socially with different user groups (Kokwe, 1995). *Dambos* are key resource areas that small-scale farmers have utilized for several decades on a sustainable basis and, given the frequent droughts that have characterized southern Africa and the associated dismal performance of rainfed crops, mounting pressure on the use of *dambos* has been evident in the last few years.

Crop production in *dambos* occupies the entire calendar year. Early maize from *dambos* helps to alleviate the 'hunger period' (Orr and Ritchie, 2004). Vegetable production is, with some exceptions, restricted to the dry season, mainly due to the high incidence of vegetable pests and diseases as well as high water tables during the rainy season. The increased usage of *dambos* and the environmental impact in terms of soil fertility degradation and pollution resulting from indiscriminate pesticide use have not received adequate research attention. Farmers are also forced to apply pesticides excessively and often indiscriminately to protect their crops from pests and diseases. For example, farmers applied up to 19 sprays to tomato and 14 to cabbage in the wetlands of Malawi (Orr and Ritchie, 2004). Some of the pesticides used are extremely hazardous (WHO Class 1). These wetlands are also intensively used for fish farming and as a source of water for animals and for domestic purposes. As a *dambo* is by nature located near or at the head of a drainage system, pesticide application to vegetables is likely to contaminate water sources in the drainage system. The continued use of chemical pesticides to achieve higher vegetable yields could lead to disruption of natural control, as well as pesticide pollution.

Very few studies (Raussen *et al*, 1995; Kuntashula *et al*, 2004) have specifically analysed aspects of vegetable gardening in the *dambos* of eastern Zambia. Until recently, many countries in southern Africa paid little attention to the negative effects on the environment of chemical fertilizer and pesticide use as long as the productivity-enhancing effects were evident.

Farmers in eastern Zambia use the fish bean (*Tephrosia vogelii*) to control storage and animal pests (Sileshi and Katanga, 2002). But there has never been a systematic study to test the efficacy of *T. vogelii* or any biopesticides in vegetable production systems in eastern Zambia. This study aimed, therefore, at evaluating gliricidia leafy biomass and biological pesticides for soil fertility improvement and pest management respectively, for vegetables produced in the wetlands.

Materials and methods

Study area

The study was conducted in the *dambo*s of the Chipata district (latitude 13º 15'S, longitude 32º 36'E and an altitude of 1,015 m) of eastern Zambia. The rainfall pattern in eastern Zambia is unimodal, with about 85% falling between December and March. The average annual rainfall (estimated from 1962–2000) in the study area is 1,030 mm. Average air temperatures range from 15º to 18ºC during June–July and 21º to 26ºC during September–October (AGROMET office, Msekera, 2001). The study area is characterized by a flat to gently rolling landscape, with altitudes ranging from 900 to 1,200 m above sea level. The soils in most *dambo*s are hydromorphic (Gleysols) of a non-expanding clay type (illites), which make the soil easy to work by hand. The study site has relatively recently developed shallow soils called Entisols (Raussen *et al*, 1995). The cultivated *dambo* area in the study region is on average 0.75 ha per household. During the time of the study, about 0.13 ha per household was put to cabbage and onion production.

In 2003, a field experiment was initiated in a *dambo* (on a farmer's field) near Msekera Research Station in Chipata (13º 39'S and 32º 34'E; altitude 1,020 masl) with the aim of evaluating biopesticides on cabbage grown using gliricidia and other conventional options.

Treatments and experimental design

The treatments included in farmers' fields were:

(1) Gliricidia biomass 8 t ha^{-1} on dry matter basis. This rate was chosen on the basis that gliricidia biomass gives about 3.0–4.5% N and 0.2–0.3% P (Mwinga *et al*, 1994), and was based on our own experience showing that 8 t ha^{-1} of biomass provides sufficient N, but not the P required by either cabbage or onion.
(2) Manure (10 t ha^{-1}) + half recommended rate of fertilizer (farmer practice).
(3) Recommended rate of fertilizer at 800 kg ha^{-1} Compound D (N = 100 g kg^{-1}, P = 90 g kg^{-1}, and K = 80 g kg^{-1}) as basal dressing and 250 kg ha^{-1} urea (46% N) as top dressing.
(4) Control (crops grown without any input).

In all, 31, 9 and 4 farmers planted cabbage in 2001, 2002 and 2003 respectively, using all the above treatments. The number of farmers who planted onion totalled 12, 5 and 5 in 2001, 2002 and 2003 respectively (Table 1). Farmers fully participated in the design and layout of the experiment. Farmers suggested the addition of manure + fertilizer as one of the treatments, as this is their common practice. Farmers also suggested the use of 5 m^2 raised beds. This is also common practice, although larger beds

Table 1. Mean yields and percentage yield increase over the control (in parentheses) in vegetables due to various treatments over the control (no fertilization) on farmers' fields in eastern Zambia.

Crop	Year	Number of farmers	Control (no input)	Recommended fertilizer	Manure + fertilizer	Gliricidia
Cabbage	2001	31	17.0	57.6 (239)	66.8 (293)	43.1 (154)
	2002	9	32.0	58.9 (84)	48.7 (52)	59.1 (85)
	2003	4	19.1	48.5 (154)	63.8 (234)	51.0 (167)
Onion	2001	12	28.1	57.1 (103)	96.0 (242)	68 .0 (142)
	2002	5	15.1	32.3 (104)	*	45.4 (187)
	2003	5	25.7	33.0 (28)	*	35.7 (39)

* = Treatment not used in onion evaluation.

of up to 50 m^2 are also used. The plot layout and randomization of the experimental units was left to each individual farmer. The treatments were not replicated on each farm. Instead, farms were used as replicates.

Cabbage and onion were raised in nursery beds, and transplanted after three and four weeks respectively, to separate beds. Cabbages were spaced at 0.75 m between rows and 0.40 m within rows, and onions at 0.30 m between rows and 0.10 m within rows.

At Msekera, a replicated experiment was conducted in 2003 on one farmer's field. This experiment had all the above soil fertility management (SFM) treatments, except the manure (10 t ha^{-1}) + half the recommended rate of fertilizer treatment, as the farmer decided to use fertilizer without manure. The SFM treatments were superimposed with crop protection (CP) treatments of:

(1) Achook, a commercial oil preparation of neem (*Azaderachta indica*) at the rate of two litres per hectare;
(2) Tephrosia (*Tephrosia vogelii*) leaf extract, 1 kg leaf in 5 l water;
(3) Thuricide, a commercial preparation of the bacterium *Bacillus thuringiensis*; and
(4) no protection (control).

As there were no specific insecticide recommendations for control of the various insects in Zambia, we did not compare the crop protection treatments with any commercial insecticide. A factorial combination of the treatments was arranged in a 'randomized complete blocks' design at the farm near Msekera. The treatments were replicated three times. Tree leafy biomass was applied one to two weeks before vegetable transplanting, while fertilizer was applied as recommended (Kuntashula *et al*, 2004). The vegetables were transplanted during the months of June and July. The vegetables were raised in nurseries, and transplanted to well prepared, raised seed beds measuring 5 × 1 m. Crop protection treatments were applied twice, at one month and two months of cabbage growth.

Sampling and data analysis

In all the experiments in 2001–03, cabbages and onions were harvested after 3–4 months, while on the farm near Msekera, cabbage was harvested twice (after three months and four months) as the crop matured at different times in 2003. At harvest, cabbage and onion yields (fresh weight) were recorded. Analysis of variance was conducted using the generalized linear model (GLM) procedure, and when the F ratio showed significance at $P = 0.05$, means were separated using Tukey's Honestly Significant Difference (HSD) test.

Insect sampling was conducted twice during the growing season, on 9 and 29 October 2003. During each sampling period, all the cabbage plants in a plot were thoroughly examined and the number of diamondback moth (DBM) larvae per plot recorded. The number of plants infested by DBM, aphids and cabbage webworm were also counted, and results were expressed as the percentage of infested plants out of the total number of cabbage plants per plot. The percentage of cabbage heads seriously damaged by diamondback moth and aphids was also recorded. Cabbage plants were categorized as unmarketable if seriously damaged by DBM larvae or malformed due to aphid attack. Data were tested for normality using the UNIVARIATE procedure of SAS. As the insect counts and percentage infestation were not normally distributed, the data were transformed by the logarithmic and arcsine functions respectively, prior to statistical analysis.

Gross margin analyses were computed for cabbages grown near Msekera to determine the financial returns from the different crop production and protection options. The production options were treated as separate enterprises, and budgets were computed for each option. Enterprise budgets were defined as the total output value of a particular enterprise, less the total variable costs of the enterprise: $Gm = Gi - Vc$, where Gm = gross margin, Gi = gross income and Vc = variable costs. In this study, the price of establishing biomass banks, and time to perform various tasks such as pruning of leaves, carrying biomass, incorporation, land preparation, weeding, watering, pesticide application and harvesting was as described in Kuntashula *et al* (2004). The major figures and assumptions in the gross margin analyses at the time of this study were:

(1) For labour valuation, a casual wage rate of Zambian Kwacha (ZK) 9,634 (= US$2) per working day was used. Earlier studies and informal interviews in the surrounding study area showed that most of the labour was provided by family members (Kuntashula *et al*, 2004). Unemployment is high, so many family members only occasionally obtain this paid work,

Table 2. Mean yields (t ha^{-1} fresh weight) of cabbage grown using commercial fertilizers and gliricidia biomass in a *dambo* near Msekera research station in eastern Zambia, 2004.

Treatments	Maturity (%)		Yield (t ha^{-1})		
	First harvest	*Second harvest*	*First harvest*	*Second harvest*	*Total yield*
Control	6.8 c	93.2 a	3.4 c	28.6 b	31.9 c
Fertilizer	50.4 a	49.6 c	44.7 a	36.2 ab	80.8 a
Gliricidia 8 t ha^{-1}	25.2 b	74.8 b	15.1 b	44.6 a	59.7 b
F *value*	*19.9*	*25.8*	*25.5*	*5.7*	*57.0*
P value	*0.0001*	*0.0001*	*0.0001*	*0.0002*	*0.0001*

Note: Means followed by the same letters in a column do not significantly differ at 5% level, according to HSD.

and the opportunity cost of labour is therefore lower.

(2) Cabbage was sold at wholesale price to a supermarket (Shoprite) at an average price of ZK720 (US$0.15) kg^{-1}.

(3) The exchange rate during the period of the experiment was ZK4,800 = US$1.

Results

Effect of SFM and CP practices on vegetable yields

In the experiments conducted in 2001–03, gliricidia biomass application increased cabbage yields by 85–167%, and onion yields by 39–187% compared with the control. Application of the recommended fertilizer increased cabbage yields by 84–2,397%, and onion yields by 28–104% compared with the control. Application of manure + fertilizer resulted in a 52–293% yield increase in cabbage (Table 1).

In the replicated experiment conducted in 2003, cabbage was harvested twice because of the differences in the time to maturity of the crop, attributed to soil fertility management practices (Table 2). Over 50% of the cabbage plants in the fully fertilized plot were ready for harvest on the first date, compared with about 7% in the control plots. Over 93% of the plants in the control were only ready by the second date of harvest, compared with the 50–75% in the fully fertilized plots and the plot that received gliricidia biomass. Neither the main effect of crop protection nor the interaction effect of soil fertility management and crop protection practices significantly influenced plant maturity. Moreover, the cabbage yield did not significantly differ among crop protection (CP) practices. However, it differed significantly with soil fertility management practices ($F_{3, 62} = 20.5; P = 0.0001$) and the interaction effect of soil fertility management and CP ($F_{24, 62} = 2.8; P = 0.0007$). During the first harvest, the order of performance of the soil fertility management practices in cabbage yields was: fully fertilized > gliricidia 8 tha^{-1} > control. During the second harvest, greater cabbage yields were obtained from plots where gliricidia biomass had been applied, compared with the other treatments. The combined cabbage yield was in the order of fully fertilized > gliricidia 8 t ha^{-1} > control (Table 2).

Incidence of insect pests and natural enemies

Throughout the study period, the diamondback moth (*Pulletella xylostella*), cabbage webworm (Hellula undalis) and cabbage aphid (*Brevicorynae brassicae*) seriously attacked cabbage. Damage by the cabbage webworm started in the nursery. In the experiment conducted in 2004, extensive damage occurred on seedlings where the caterpillars fed on the growing points, and the seedlings were wiped out completely. This necessitated replanting in the nursery. Damage continued after transplanting, when the caterpillars tunnelled into the growing point, resulting in deformed plants as well as formation of multiple growing points. The damaged seedlings that survived branched profusely and failed to develop into normal sized heads.

The population of DBM larvae significantly differed with the time of sampling ($F_{1, 62} = 29.5; P = 0.0001$) and among CP practices ($F_{3, 62} = 7.0; P = 0.0004$). However, it did not differ among soil fertility management practices or due to the interaction effect of time of sampling, soil fertility management and crop protection practices. On both sampling dates, the population of DBM larvae per plot was significantly higher in cabbage that had received no crop protection measures (except Achook) compared with the protected plots during the first sampling. On the second date of sampling, cabbage grown using gliricidia biomass and without any inputs had a significantly higher density of DBM larvae compared with cabbage grown using commercial fertilizer (Table 3). The percentage of cabbage plants infested by DBM larvae differed between sampling dates ($F_{1, 62} = 443.1; P = 0.0001$) and the interaction effect of time of sampling, SFM and CP ($F_{24, 62} = 1.8; P = 0.032$). The percentage of unmarketable cabbage heads as a result of DBM was significantly higher in the plots that had received no protection compared with the protected plots (Table 4).

The percentage of plants infested with aphids significantly differed with sampling dates ($F_{1, 62} = 6.1; P = 0.016$) and crop protection practices ($F_{3, 62} = 24.9; P = 0.0001$). Aphid infestation was generally higher on the first sampling date than the second. On both sampling dates, infestation was significantly lower in cabbage plants treated with Tephrosia leaf extract compared with all other treatments (Table 3). Aphid infestation did not differ among SFM practices or from the interaction effect of SFM and CP practices. The highest and lowest

Table 3. Effect of crop protection practices on the incidence of insects in cabbage planted in a *dambo* near Msekera research station in eastern Zambia.

Time of sampling	Treatments	Diamondback moth larva density (number per plot)	Diamondback moth infestation (% plants)	Aphid infestation (% plants)	Cabbage webworm infestation (% plants)	*Aphidius* population (number per plot)
First	No protection	10.2 a	10.8	72.2 a	1.4	32.4
	Achook	5.2 ab	7.0	63.7 a	0.9	38.0
	Tephrosia	4.1 b	4.7	43.2 b	0.4	21.5
	Thuricide	4.0 b	5.1	60.1 a	0	32.9
	F value	*3.60*	*2.13*	*12.26*	*0.90*	*1.44*
	P value	*0.021*	*0.110*	*0.0001*	*0.447*	*0.245*
Second	No protection	15.5 a	48.2	67.9 a	21.2 a	
	Achook	7.8 b	46.0	60.9 a	9.8 b	
	Tephrosia	7.2 b	41.3	34.6 b	5.8 b	
	Thuricide	10.5 b	48.5	46.8 b	13.1 ab	
	F value	*9.88*	*0.89*	*13.27*	*5.00*	
	P value	*0.0001*	*0.456*	*0.0001*	*0.005*	

Note: Means followed by the same letters in a column do not significantly differ at 5% level, according to HSD.

Table 4. Effect of crop protection practices on the damage by the diamondback moth and aphids on cabbage planted in a *dambo* near Msekera research station in eastern Zambia.

Time of sampling	Treatments	Cabbage heads seriously damaged by diamondback moth larva	Cabbage heads seriously damaged by moths
First	No protection	9.1 a	8.2 a
	Achook	0.6 b	0.8 b
	Tephrosia	0 b	0.5 b
	Thuricide	1.9 b	2.6 ab
	F value	*12.82*	*5.40*
	P value	*0.0001*	*0.0040*

Note: Means followed by the same letters in a column do not significantly differ at 5% level, according to HSD.

percentage of unmarketable cabbage heads (seriously malformed due to aphid attack) was recorded in the unprotected plots and those protected with Tephrosia leaf extract respectively (Table 4). Populations of the aphid parasite *Aphidius* spp. was influenced by the interaction effect of SFM and CP practices ($F_{9, 30} = 2.3; P = 0.046$). However, it was not affected by either SFM or CP practices individually. Although fewer *Aphidius* spp. were recorded in cabbage treated with Tephrosia, the differences among treatments were not significant (Table 3).

The percentage of cabbage plants infested with cabbage webworm larvae differed between sampling dates ($F_{1, 62} = 58.8; P = 0.0001$) and CP ($F_{3, 62} = 5.4; P = 0.0023$). Infestation was lower on the first sampling date than the second (Table 3). Differences between the crop protection practices were noted only on the second sampling date, when plants that had received no protection and Thuricide spray had significantly higher infestation compared with those treated with Tephrosia leaf extract or Achook. Cabbage webworm infestation did not differ among SFM practices or due to the interaction effect of time of sampling, SFM and CP practices.

Cabbage yield was not correlated with either the population density of DBM larvae or the percentage of plants infested with larvae or aphids. However, there was a significantly negative correlation between the percentage of plants infested with cabbage webworm and cabbage yield at the second harvest ($r = -0.40, N = 48; P = 0.0052$) and combined yield ($r = -0.29, N = 48; P = 0.049$).

Net incomes from different production options

Net incomes from cabbage grown using commercial fertilizer and gliricidia biomass were substantially higher than the net income from the control. The highest net incomes were obtained from the fully fertilized plots. The structure of costs differed between the full fertilization and the gliricidia biomass application. Full fertilization demanded more cash outlay, while gliricidia biomass application demanded more labour (Table 5). SM practice in the absence of CP recorded slightly higher net incomes. The major cost for Tephrosia extract was in the form of labour for harvesting the leaves and crushing them. On the other hand, the major cost for Thuricide and Achook was the actual cash needed to buy the crop protection inputs (Table 5).

Discussion and conclusion

The results from several farms and for a period of four years showed that gliricidia leafy biomass could produce vegetable yields comparable with those obtained from chemical fertilizers. Gliricidia leafy material is an organic resource with high nitrogen content and is known for its fast release of nutrients for crop uptake (Mafongoya *et al*, 1997). In southern African countries where most small-scale farmers have no access to chemical fertilizer,

Table 5. Gross margins from cabbage produced using various soil fertility management and crop protection methods.

		Treatments			
		Control	*Fertilizer*	*Gliricidia 8 t ha^{-1}*	*Gliricidia 12 t ha^{-1}*
Outputs					
	Average yield (t ha^{-1})	31.9	80.8	59.9	67.1
Total revenue (US$ ha^{-1})		4,785	12,120	8,985	10,065
	Tephrosia extract	173	604	192	192
	Thuricide	204	635	223	223
	Achook	248	679	267	267
Cash costs (US$ ha^{-1})	No pesticide	173	604	192	192
	Tephrosia extract	686	720	938	1,048
	Thuricide or Achook	658	692	910	1,020
Labour costs (US$ ha^{-1})	No protection	608	642	860	970
Total costs (US$ ha^{-1})					
	Tephrosia extract	859	1,324	1,130	1,240
	Thuricide	862	1,327	1,133	1,243
	Achook	906	1,371	1,177	1,287
	No protection	781	1,246	1,052	1,162
Gross margins (US$ ha^{-1})					
	Tephrosia extract	3,926	10,796	7,855	8,825
	Thuricide	3,923	10,793	7,852	8,822
	Achook	3,879	10,749	7,808	8,778
	No protection	4,004	10,874	7,933	8,903

Notes: Labour costs include those of making and applying the crop protection methods, cutting and ferrying of the leafy biomass and applying the soil fertility methods. See Kuntashula *et al*, 2004. Total revenue calculated at US$150 t^{-1}; labour costs at US$2 man-days^{-1}.

gliricidia leafy biomass could offer a sustainable alternative, provided adequate labour was available. The fact that cabbage grown using commercial fertilizer matures earlier than cabbage grown using gliricidia leaf biomass is probably because nutrients are released faster from commercial fertilizer than from the gliricidia biomass. In the event that the rate of nutrient release and crop uptake is not synchronized, pollution through leaching is expected to be high with inorganic fertilizers. On the other hand, the maturity of cabbage at different times has important implications for their exposure to pest attack and also for marketing the vegetable. Late maturing plants could be exposed more to pest attack compared with those that matured early. In eastern Zambia, where farmers grow cabbage and other vegetables at the same time, the spreading of harvests could help in stabilizing the otherwise depressed prices during glut periods.

The infestation by diamondback moth larvae reached 50%, while aphid infestation was as much as 70%. Although cabbage webworm infestation was generally low, it appeared to have more negative impact on yield than either DBM or aphids. This is probably because the larvae prevent the formation of proper cabbage heads, while damage caused by DBM is often just cosmetic. These pests seriously damage cabbage in southern Africa (Dobson *et al*, 2002), and farmers tend to apply pesticides frequently and indiscriminately to control cabbage pests (Orr *et al*, 1999). This excessive application of pesticides has serious implications for the sustainability of the practice. The diamondback moth has become resistant to various chemical insecticides (Magaro and Edelson, 1990) as well as microbial ones such as *Bacillus thuringiensis* (Tabashnik *et al*, 1990). In this study, the leaf extract of Tephrosia gave better protection than the commercial formulation of *Bacillus thuringiensis*. We do not yet know whether the strain of DBM in Zambia has developed resistance to any of the commercial pesticides. Further studies are needed to confirm these results over a wider geographic area in the country.

The financial implication for the use of pesticides is that farmers are better off not applying pesticides such as Thuricide. Among the three alternatives evaluated, Tephrosia extract was the most cost effective, although it demands labour for making the concoction. Several studies have found that it was profitable to use biomass transfer technologies, for example, with gliricidia, in high-value crop production of vegetables (Brummett and Noble, 1995; Kuntashula *et al*, 2004). Farmers who participated in this trial were happy with the performance of gliricidia, and have planted biomass banks in their fields. From these observations, it is concluded that for resource-poor farmers who form the majority in most southern African countries, gliricidia biomass as an SFM practice and Tephrosia extract as a CP practice could offer opportunities for sustaining vegetable production in the wetlands. However, there is a need for wider testing of these practices across sites of different soil types and during different seasons.

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