Journal of Tropical Agriculture 49 (1-2) : 58-63, 2011

Economic analysis of fungicide and fertilizer applications on huckleberry (*Solanum scabrum* Mill.) fresh shoot yield

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Received 27 October 2010; received in revised form 22 June 2011; accepted 01 July 2011

Abstract

An economic analysis of fungicide and fertilizer applications on huckleberry fresh shoot yield was carried out in August-December 2006 and in March-July 2007. Six varieties (SS05.1, S18, SS08, SS19, SS25.1, and SS01), four levels of fertilization (unfertilized, mineral fertilizer (NPK), and 10 and 20 Mg ha^{-1} of poultry manure), and fungicides were evaluated in a split plot trial. The sub-plots received Ridomil Plus® (12% metalaxyl + 60% cuprous oxide), at a rate of 2.5 kg ha^{-1} on appearance of first foliar late blight symptoms. Fungicide application reduced late blight severity. Yield increase due to fungicide application was as high as 16.14 Mg ha^{-1}. Fertilizer application increased fresh shoot yields (range: 0.60 to 46.18 Mg ha^{-1}). However, poultry manure application increased both huckleberry yields and late blight infestations. In economic terms, the results showed a maximum benefit of € 3494 ha^{-1}due to fungicide application. The net benefit due to fertilizer application varied between € 28 and €1514 ha^{-1} for NPK; € 455 and € 3120 ha^{-1} for 10 Mg ha^{-1} of poultry manure; and € 328 and € 9258 ha^{-1} for 20 Mg ha^{-1} of poultry manure. Variety SS05.1 gave the highest net benefit due to fungicide and fertilizer applications and is therefore recommended where the pesticides are available. Variety SS25.1 is resistant to late blight and high yielding and therefore could be cultivated without fungicides, with or without fertilizers.

Keywords: Economics analysis, Fertilization, Fungicide, Poultry manure.

Introduction

Huckleberry (*Solanum scabrum* Mill.) is one of the most important indigenous leafy vegetables in Africa. It occurs as a cultivated vegetable in Sub Sahara African countries like Cameroon, Ethiopia, Liberia, Mozambique, Nigeria and South Africa. Outside Africa, huckleberry is found in Europe, Asia (India, China and the Philippines), Australia, New Zealand, North America and the Caribbean (Fontem and Schippers, 2004). Its leaves and fresh shoots are widely used as cooked vegetable, which is served with a variety of food such as plantains (*Musa* spp.), sweet potatoes (*Ipomoea batatas* (L.) Lam.), potatoes (*Solanum tuberosum* L.), yams (*Dioscorea* spp.), maize (*Zea mays* L.) or pounded cocoyams (*Xanthosoma sagittifolium* (L.) Schott, and *Colocasia esculenta* (L.) Schott). It is widely used as a medicinal plant, fodder for cattle and goats, and as a source of dyes or as a kind of ink.

Huckleberries require high amounts of nitrogen and other nutrients. Consequently, they do well in soils that are rich in organic matter and on soils covered with ash from recently burnt vegetation. However, a major constraint to huckleberry cultivation is the prevalence of pests (weeds, insects, nematodes, and snails) and diseases (late blight, early blight, and bacterial wilt). During heavy rains, late blight caused by *Phytophthora infestans* (Mont.) de Bary is the most important malady to huckleberry cultivation especially when planting

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density is high. Yield losses of up to 100% have been reported for susceptible cultivars in the nursery (Fontem and Schippers, 2004) and up to 46 % in the field (Fontem et al., 2003).

Chemical control is the fastest and most widespread disease management method used to control late blight. Fungicides maneb, mancozeb, cuprous oxide and Ridomil Plus® (metalaxyl 60 + cuprous oxide 12) have been used to manage late blight infections in Cameroon. Ridomil Plus® has been effectively used on huckleberry to manage late blight (Fontem et al., 2003). However, an economic evaluation of these fungicides on huckleberry cultivation has not been attempted. This study aimed to analyse the economics of fungicide and fertilizer applications in huckleberry cultivation.

Materials and Methods

Two field experiments were conducted during the 2006 and 2007 growing seasons at the University of Dschang Research and Experimental Farm (5º26'N, 10º04'E, 1400 m) in West Region of Cameroon in plots that grew no solanaceous crops for the past four years. The experiments were conducted in a randomised split-plot design with three replications. Varieties (six) and fertilizer levels (unfertilized, mineral fertilizer at 120 kg ha^{-1}, poultry manure at 10 and 20 Mg ha^{-1}) were assigned to the main plots while fungicide applications (Ridomil Plus® sprayed and unsprayed) formed the subplots. Each plot was separated by a 1 m wide crop-free zone to limit neighbouring plot interferences.

Six morphologically distinct huckleberry varieties (Berinyuy et al., 2002) were used in both years. Variety SS05.1 has large leaves with white corolla and variety SS18 has large leaves with purple corolla. Varieties SS08 and SS25.1 are both medium leaf-sized with white corolla but the former has green stems while the latter has purple stems and branches. Variety SS19 differs from variety SS08 by its large fruits and striped coloured flowers. Variety SS01 has small sized leaves with purple stems and branches, white corolla and no stem teeth contrary to all the other five varieties that possess stem teeth.

During each year of the trial, two nursery beds (10 x 1.2 m) were prepared and poultry manure applied at the rate of 4 Mg ha^{-1}. The nurseries were sown on 8 July 2006 and 17 March 2007 and seeds were sown 5 cm apart in rows spaced 10 cm. Seedlings received two foliar sprays of maneb (Trimangol 80 WP) at 14 and 28 days after sowing (1.6 kg a.i. ha^{-1}) and deltamethrin (Decis 25 EC) at 0.7 L ha^{-1} before transplanting. Seedlings (8 to 15 cm tall) which had 5 to 6 true leaves were transplanted at 0.3 x 0.3 m spacing on beds (1.8 x 1.8 m). In the field, plants were sprayed with deltamethrin to control insect pests every 14 days. The field was hand weeded and tilled thrice, at 21 day intervals.

Poultry manure was applied on field beds at the rate of 10 and 20 Mg ha^{-1} two days before transplanting. Mineral fertilizer (NPK 20-10-10) was applied at 120 kg ha^{-1} in bands, 5 cm from the main stem at a shallow depth, 5 days after transplanting and repeated after the second harvest (41 and 48 days after transplanting, DAT, during 2006 an 2007, respectively). Half of each main plot received five foliar sprays of Ridomil Plus® (72 WP) at 2.5 kg ha^{-1} to control late blight while the other half was unsprayed. The first fungicide application using a knapsack sprayer (Solo Kleinmotoren GmbH, Sindelfingen, Germany) was made when first foliar symptoms appeared at 14 and 18 DAT in 2006 and 2007, respectively. A 2.5 x 2.1 m plywood sheet was held between subplots during spraying, to prevent fungicide drift.

Plants were harvested on a 14 day cycle from 22 and 31 DAT during 2006 and 2007 planting seasons, respectively. After harvesting the fresh shoots, diseased leaves were discarded while clean shoots were weighed for each sub-plot, using a hand-held balance. Marketable yields were expressed in kilogramme fresh weight per hectare. Cumulative fresh yields for the different treatments were subjected to analysis of variance (ANOVA) using MSTATC statistical package. Means were separated using Duncan's Multiple Range Test at $p = 0.05$.

Economic evaluation of fungicide and fertilizer applications

Economic analysis for fungicide and fertilizer applications was done using partial budgeting (Alima and Manyong, 2000) since costs of land preparation, nursery preparation and maintenance, transplanting, weeding, fertilizer application and insect management were the same for all treatments. Farm gate prices were used for analyses of fungicide and fertilizer applications. The cost of spraying one hectare of huckleberry with fungicide (d) was calculated as $d = ((Q \, X \, CF) + CL) \, n$, where Q = quantity of fungicide applied (2.5 kg ha^{-1}), CF = cost of fungicide (€15 ha^{-1}), CL = cost of labour used in fungicide application for a hectare of huckleberry (€7.7) and n= number of fungicide applications (five times). NPK costs were € 0.38 and € 0.42 kg^{-1}, which gave a total of 92 and €100 ha^{-1} for two applications at 120 kg ha^{-1} during 2006 and 2007, respectively. During both years, a tonne of poultry manure was sold at € 62. The cost of transportation (4 km distance) was €1.8 for NPK 20-10-10 and, € 62 and €123 for 10 and 20 Mg ha^{-1} of poultry manure respectively. Fertilizer application charges were € 38 ha^{-1} for NPK and € 54 ha^{-1} for poultry manure. Cost of fertilization (CF) was taken as the sum of the cost of fertilizer, cost of transportation, and cost of application.

Farm gate prices of 0.31, 0.38, and € 0.46 kg^{-1} for large, medium, and small leaf sizes were established from a survey of 160 huckleberry producers and 40 local vendors. These prices were used to estimate the total returns. Increase in fresh shoot yields in sprayed over unsprayed treatments and in fertilized over unfertilized treatments were assumed to be solely due to fungicide and fertilizer applications. Total returns were the values of the marketable yields obtained in sprayed (a) and unsprayed (b) sub-plots. Net returns (c) due to fungicide application were the difference in total returns on sprayed and unsprayed sub-plots ($c = a–b$). Net benefit (e) was calculated as the difference between the net return and total cost of fungicide application ($e = c–d$). Rate of return, defined as the number of times fungicide application cost was recouped from the value of increased yield, was computed as $RR = e/d$.

Net return, net benefit, and rate of return due to fertilization were calculated in the same way as the difference in income between the yields of huckleberry in fertilized and unfertilized plots of the same variety, the difference between net return and cost of fertilization, and the number of times each unit cost of fertilizer application yielded income.

Results and Discussion

Cumulative fresh shoot yields

Varietal response to fungicide and fertilizer applications on fresh shoot yield of huckleberry is presented in Table 1. During 2006, no significant difference (p >0.05) in huckleberry yields due to variety on the unfertilized and sprayed sub-plots were recorded. Treatment with NPK application showed that SS25.1 (14.82 Mg ha^{-1}) gave the highest yield, while with 20 Mg ha^{-1} of poultry manure SS05.1 (23.73 Mg ha^{-1}) gave the highest yield. The results show that variety SS25.1 was both tolerant to late blight as well as high yielding.

The interaction effect (variety x fertilizer application) was significant (p = 0.05) during 2007. This implies that both variety and fertilization are important in the cultivation of huckleberry and the choice of one factor without due consideration of the other two may not give the optimum results. Yield increases of up to16.14 Mg ha^{-1} were obtained due to fungicide application, 6.14 Mg ha^{-1} due to fertilizer application with NPK, 16.17 Mg ha^{-1} for 10 Mg ha^{-1} poultry manure, and 46.17 Mg ha^{-1} for 20 Mg ha^{-1} of poultry manure. Huckleberry yields for this study are comparable with those obtained by Engonga (2007) but lower than those obtained by Fontem et al. (2003). The lower yields for this study could be attributed to low precipitation during the experimental period.

Economic returns from fungicide application

Table 2 presents data on the effect of fungicide application on huckleberry for economic returns in 2006 and 2007 growing seasons. For both years net benefits were low for unfertilized unsprayed treatments. In addition,

Table 1. Varietal response to fungicide and fertilizer applications on fresh shoot yields of huckleberry during 2006 and 2007 at Dschang in West Region of Cameroon.

Year	Variety	Unfertilized		Mineral fertilizer		Poultry manure (Mg ha^{-1})			
						10		20	
		Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
2006	SS05.1	6.13ab	5.12ab	9.03b	8.91b	11.34bc	9.49b	23.73a	19.93a
	SS18	5.48b	5.44ab	7.06b	6.23b	12.04ab	10.19ab	17.29b	14.58a
	SS08	4.17	4.05ab	8.45b	7.30b	14.12ab	10.12ab	19.21b	14.59a
	SS19	3.82	3.82b	4.86b	4.63b	7.18d	6.83b	8.33c	6.71b
	SS25.1	10.30 b	9.38a	14.82a	14.35a	16.09a	14.82a	16.90b	15.05a
	SS01	5.00 b	4.82ab	5.60b	5.42b	7.52cd	7.18b	9.37c	8.68b
2007	SS05.1	7.64	6.48a	13.77a	11.86a	22.80a	20.14a	53.82a	37.68a
	SS18	8.10	6.94a	10.07a	8.22a	21.07a	16.47a	44.56b	34.26a
	SS08	8.45	8.22a	10.65a	10.42a	15.28abc	14.01a	27.43cd	23.61b
	SS19	3.88	3.70a	4.63b	4.44a	10.65c	10.19a	16.55e	14.39c
	SS25.1	8.10	7.99a	10.88a	10.88a	16.67abc	15.97a	31.95c	29.75b
	SS01	5.44 b	5.09a	8.22ab	7.64a	12.85bc	11.92a	22.57de	20.26bc

Means within a column followed by the same letters are not significantly different according to DMRT (p=0.05) for each year

unfertilized plots and those with NPK treatment gave low rates of return for unsprayed treatments. During 2006, poultry manure applications of 20 Mg ha^{-1} gave the highest net benefits due to fungicide application and high rates of return.

Application of fungicide for the control of huckleberry late blight could thus be advisable when cultivating varieties such as SS19, SS25.1 and SS01 where poultry manure is applied. For both years, fungicide application was beneficial for late blight resistant variety cultivated with 20 Mg ha^{-1} of poultry manure and susceptible varieties cultivated with 10 and 20 Mg ha^{-1} of poultry manure. Fungicide application, however, was not economically beneficial under these conditions on plots that did not receive poultry manure. This is consistent with the results of a field study by Fontem et al. (2003) who reported economic losses of up to $8467 ha^{-1}.

Economic returns from fertilizer application

A comparison of the data on yield returns following fertilizer application on huckleberry during 2006 and 2007 cropping seasons indicate that side-dressing with NPK was cheaper than poultry manure application (Table 3). The total returns and net benefits from NPK side-dressed plots were lower than plots that received poultry manure. Net benefits were high for varieties SS25.1, SS08 and SS05.1 (>€760 ha^{-1}) with NPK application, and were low for varieties SS18 (€258 ha^{-1}), SS19 (€178 ha^{-1}), and SS01 (€145 ha^{-1}).

During 2007, fertilizer application gave high net returns on all treatments, apart from NPK application on variety SS19 (€77 ha^{-1}). Net returns varied from €609 to €9258 ha^{-1} with 20 Mg ha^{-1} of poultry manure application. Based on the net return and benefit-cost ratios, fertilizer application increased fresh shoot yields during 2007 more than during 2006.

For both years, varieties that gave high net returns due to fertilizer application also had high net benefits. Varieties SS01 and SS19 responded least to fertilizer applications and thus the least farm income were derived from them. This is consistent with the farmers' practices: farmers who grow SS01 variety rarely use fertilizers and fungicides compared to farmers who grow SS18. Similar findings were reported by Nzila et al. (2007) who studied the impact of organic and mineral fertilizer (poultry manure, NPK 15-15-15 or both) on the production of vegetable crops (*Basella alba* L. and *Amaranthus cruentus* L.) in Congo and reported that

Table 2. Effect of fungicide application on huckleberry economic returns at Dschang, Cameroon (in Euros).

		2006					2007				
Fertilization	Variety	Total returns SP (a)	US (b)	Net return (c= a–b)	Net benefit (e=c–d*)	R R (f=e/d)	Total returns SP (a)	US (b)	Net return (c= a–b)	Net benefit (e=c–d)	R R (f=e/d)
Unfertilized	SS05.1	1886	1603	283	52	0.2	1754	1495	258	27	0.1
	SS18	1782	1674	108	–123	–0.5	1869	1602	268	37	0.2
	SS08	1605	1558	46	–185	–0.8	2437	2371	66	–165	–0.7
	SS19	1469	1469	0	–231	–1.0	1120	1067	53	–178	–0.8
	SS25.1	3962	3592	369	138	0.6	2337	2305	32	–199	–0.9
	SS01	2308	2225	83	–148	–0.6	1922	1769	152	–79	–0.3
NPK	SS05.1	2778	2742	37	–194	–0.8	3178	2737	442	211	0.9
	SS18	2172	1917	255	24	0.1	2325	1897	428	197	0.9
	SS08	3251	2808	443	212	0.9	3072	3006	66	–165	–0.7
	SS19	1782	1782	0	–231	–1.0	1336	1281	55	–176	–0.8
	SS25.1	5700	5520	180	–51	–0.2	3138	3138	0	–231	–1.0
	SS01	2585	2502	83	–148	–0.6	2838	2631	208	–23	–0.1
PM 10 Mg ha^{-1}	SS05.1	3489	2920	569	338	1.5	5262	4648	614	383	1.7
	SS18	3705	3135	569	338	1.5	4863	3802	1062	831	3.6
	SS08	5431	3892	1538	1307	5.7	4408	4038	369	138	0.6
	SS19	2762	2628	134	–97	–0.4	3072	2940	132	–99	–0.4
	SS25.1	6189	5700	489	258	1.1	4809	4606	203	–28	–0.1
	SS01	3471	3314	157	–74	–0.3	4448	4126	322	91	0.4
PM 20 Mg ha^{-1}	SS05.1	7305	5520	1785	1554	6.7	12420	8695	3725	3494	15.1
	SS18	5320	4489	831	600	2.6	10283	7906	2377	2146	9.3
	SS08	7389	5612	1777	1546	6.7	7915	6811	1105	874	3.8
	SS19	3205	2582	623	392	1.7	4774	4151	623	392	1.7
	SS25.1	6500	5789	711	480	2.1	9217	8582	635	404	1.8
	SS01	4325	4006	318	87	0.4	7812	6992	820	589	2.5

*d=€231, SP= Sprayed, US = Unsprayed, RR= Rate of Return; PM=poultry manure.

no significant yield increases can be derived from mineral fertilizer application alone. Alongamo (2008) posits that a basal application of poultry manure is necessary before mineral application for increased yield and thus farm income.

Conclusions and recommendations

The results of the study indicate that there are economic gains with fungicide and fertilizer applications on huckleberry cultivation. Fungicide application reduced late blight severity implying that fungicide has been effectively used to manage late blight infestations. Fertilizer application increased fresh shoot yields. This study provides a justification for the need to increase the supply of huckleberry, an important indigenous leafy vegetable in Africa and other parts of the world. It will be interesting to carry out this study in other agro-ecological zones of Cameroon, and a pesticide residue analysis should be conducted under the same conditions to check that the residues are below the maximum residue limits following Codex Alimentarius. Trials could also be carried out with a basal application of poultry manure (10 Mg ha^{-1}) before fertilizer and fungicide applications.

Table 3. Effect of fertilizer application on huckleberry economic returns at Dschang, Cameroon (in Euros).

Fertilization	Variety	2006					2007				
		Total returns		Net Returns (c)	Net benefit (e=c–d)	RR (f= e/d)	Total returns		Net Returns (c=a–b)	Net benefit (e=–d)	RR (f=e/d)
		F(a)	UF (b)				F(a)	UF (b)			
NPK	SS05.1	2778	1886	892	760	5.8	3178	1754	1425	1285	9.2
	SS18	2172	1782	391	259	2.0	2325	1869	455	315	2.3
	SS08	3251	1605	1646	1514	11.5	3072	2437	635	495	3.5
	SS19	1782	1469	312	180	1.4	1335	1168	168	28	0.2
	SS25.1	5520	3962	1558	1426	10.8	3138	2337	802	662	4.7
	SS01	2585	2308	277	145	1.1	2846	1602	1245	1105	7.9
PM 10 Mg ha^{-1}	SS05.1	3489	1886	1603	895	1.3	5262	1754	3508	2800	4.0
	SS18	3705	1782	1923	1215	1.7	4863	1869	2994	2286	3.2
	SS08	5431	1605	3826	3118	4.4	4408	2437	1971	1263	1.8
	SS19	2762	1469	1292	584	0.8	3072	1168	1905	1197	1.7
	SS25.1	6189	3962	2228	1520	2.1	4809	2337	2472	1764	2.5
	SS01	3471	2308	1163	455	0.6	4448	1602	2846	2138	3.0
PM 20 Mg ha^{-1}	SS05.1	7305	1886	5418	4010	2.8	12420	1754	10666	9258	6.6
	SS18	5320	1782	3538	2130	1.5	10283	1869	8414	7006	5.0
	SS08	7389	1605	5785	4377	3.1	7915	2437	5478	4070	2.9
	SS19	3205	1469	1735	327	0.2	4774	1168	3606	2198	1.6
	SS25.1	6500	3962	2538	1130	0.8	9217	2337	6880	5472	3.9
	SS01	4325	2308	2017	609	0.4	7812	1602	6211	4803	3.4

Cost of fertilization: poultry manure (PM) 10 Mg ha^{-1} = €708, poultry manure 20 Mg ha^{-1} = €1408, NPK €132 in 2006 and €140 in 2007, F= fertilized plot, UF= unfertilized plot, RR = rate of return

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