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Economic Analysis of Plant Extracts Usage in Cowpea Root-rot Control in the Federal Capital Territory, Abuja, Nigeria

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ABSTRACT

The indigenes of the Federal Capital Territory (FCT), Abuja, Nigeria are known for their usage of botanical pesticides for crop protection but there is limited information on the profitability or otherwise of these local phytopesticides. This study analysed the cost and returns of cowpea production applied with aqueous and ethanolic leaf extracts of neem (*Azadirachta indica*) and iron weed (*Blumea perotitiana*) for the control of *Rhizoctonia* root-rot (RRR) in 2006 and 2007 in the FCT-Abuja, Nigeria. Cowpea production on the synthetic fungicide (mycotrin®) applied plots had the highest net income than all other treatments in the two locations (₦31688.48 ha^{-1} & ₦35946.67 ha^{-1}), respectively. Net income from the fungus-inoculated plots with no fungicide application was negative indicating a loss in Ido and Kwali fields (₦2195.74 & N1095.83 ha^{-1}), respectively. Among the plant extracts used, combined aqueous extracts of *A. indica* and *B. perotitiana* in Kwali field had the highest net income (₦23296.83 ha^{-1}).

Key Words: Control; Cowpea root-rot; Economic analysis; Plant extracts

INTRODUCTION

The largest production of cowpea is in Africa, with Nigeria and Niger predominating. Its market price fluctuates due to normal production and demand factors (Idem, 2005). Cowpea protection with botanicals appears to have a prominent role for the development of future commercial pesticides through, which the production of the crop would be boosted and safety of the environment and public health are ensured. Nigeria has abundant pesticidal plant materials, which are often available during the cropping season and which could be exploited, prepared locally and used on both small and moderately large farms especially by poor-resource farmers (Ajikwa *et al.*, 2001; Shahida *et al* 2002; Yar'adua, 2007). Due to the high cost of procuring and applying synthetic pesticides, which made it un-affordable by many Nigerian farmers, most of them only use it as a last resort or when the governmental authority can afford to offer assistance (Salako, 2002).

In order to contribute to the limited information on economics of using botanical and synthetic pesticides, assessment of economic impact of cowpea root-rot control with plant extracts and synthetic fungicide (mycotrin®) in the Federal Capital Territory, Abuja-Nigeria was undertaken. Comparison of the net income and return per naira invested of applying water and ethanolic fungicidal plant extracts on the cowpea farm was done. This is to find methods, which have high efficacy against cowpea root-rot, while maintaining production and profits.

MATERIALS AND METHODS

Production and application of the fungicidal plant extracts in Ido and Kwali, FCT-Abuja was carried out in 2006 and 2007. The experimental field is geographically located in the heartland of Nigeria and falls between Lat. 08^{o} 25^{l} and 09^{o} 21^{l} N of the Equator and Long. 6^{o} 45^{1} and 7^{o} 39^{1} E of the Greenwich Meridian in the southern Guinea savanna agroecolgical zone of Nigeria. The crude phytofungicides produced involved water and ethanol extraction methods.

Land preparation and field layout. The field in each of the locations was cleared and ridges were made manually using hoes. Ridges were made at 75 cm apart and seeds were sown on ridges 30 cm apart. The cowpea (*Kanannado* variety) planted was obtained from FCT-ADP Seed Multiplication Unit in Gwagwalada, Abuja. This variety is known for its susceptibility to root-rot fungus attack. The seeds were sown on the 20^{th} and 23^{rd} of August in 2006 and 2007 in each location, respectively. Three seeds were sown per stand and later thinned to two seedlings per stand 10 days after sowing (DAS). A plot was made up of five rows

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and was separated from each other with an un-sown ridge. Each plot in a block received a treatment and was labeled accordingly.

Preparation and application of extracts and inoculum. Fresh healthy leaves of *A. indica and B. perotitiana,* were collected from Kuje and Gwako in the Federal Capital Territory in June, 2006. In the Biology laboratory of University of Abuja, the materials were thoroughly washed in running water, chopped into tiny pieces (2-3 mm) and spread on pre-cleaned laboratory benches for 2 weeks to dry. The dry leaves were ground with a pre-cleaned grinder and then sieved. Five kilogram of the leaves powder was soaked separately for 24 h in 4 L distilled water in a plastic can. These were thoroughly shaken before the resulting slurry from each was filtered through a layer of cheese cloth. For the ethanolic extraction, 5 Kg each leaf powder was cold extracted with 2 L ethanol for 3 days to obtain the bioactive ingredients. The extracted materials with each of the solvent were concentrated with rotary vacuum evaporator at 50°C. The recovered ethanol was poured back into the filtrate to ensure thorough extraction. The jelly-like extracts were finally concentrated using water bath to make it the fungicidal product.

The duly identified preserved sample of *R. solani* inoculum was obtained in the biology laboratory of University of Abuja was sub-cultured and grown on a prepared aseptic Oxoid medium in sterile Petri dishes. They were incubated at 27°C and after 72 h fan-like radial mycelia grew from the rhizomorphs. The fungus inoculum was applied on the surface of the ridge and lightly covered with top soil a week before sowing (WBS) so that they can stabilize in the soil before seed sowing. Nine treatments were involved in each of the two locations in 2005 and 2006 as shown in Tables I and II.

A synthetic systemic fungicide - maneb + zinc (Mycotrin®) was used for seed dressing and soil drenching of a plot per block. This served as positive control for the purpose of comparison. The seeds were dressed with each of the extracts (7.5 g kg^{-1} of seeds) before planting. At 12 DAS, rhizosphere of plants in the appropriate plots was drenched with 50 mL of each type of extract (100 g L^{-1} of water). During the growing period each field was hoe-weeded twice. Thereafter, hands were used for light weeding. Karate (5 mL L^{-1} of water) was applied at 3 WAS, after flowering and at podding on all the plots in order to control insect pests. At 2 WAS, the number of dead seedlings per plot were counted and recorded. At 3 WAS, plants in the two border rows of each plot were carefully lifted with ball of earth. Indexing for root rot was done and recorded on a 0 - 4 scale in line with Sidhu and Webster (1977). Soil from the rhizosphere (200 g) and root samples of each of the uprooted plants were collected in 10 cm diameter clean polypots and labeled accordingly. In the biology laboratory of University of Abuja, gall rating, sieving and quantification of the *Meloidogyne* spp. population under the microscope was carried out for each plot, respectively.

Table I. Estimated operating costs per hectare and returns of cowpea yield per kilogram used for computation

Description of operating costs	**Rate(₦)**
Farmland rent/year	3000.00
Land preparation and layout	10000.00
Collection and drying of leaves (50 kg)	12.00 kg^{-1}
Grinding/sieving of leaves	300.00 kg^{-1}
Ethanol (10 L)	1000.00 L^{-1}
Extraction and concentration	10.00 kg^{-1}
Mycotrin®	2000.00 kg^{-1}
Seeds (23 kg)	120.00 kg^{-1}
Sowing	1500.00 ha^{-1};
Thinning and drenching with fungicides	1500.00 ha-1
Weeding (twice)	8000.00 ha^{-1}
Karate®) insecticide application	5800.00 ha^{-1}
Harvesting/ shelling	4000.00 ha^{-1}
Marketing of grains	5.00 kg^{-1}
Marketing of pod shells	2.00 kg^{-1}
Fodder production and marketing	2.00 kg^{-1}
Returns of cowpea yield per kilogram	**Rate(₦)**
Cowpea grains	100.00 kg^{-1}
Pod shells	5.00 kg^{-1}
Fodder	3.00 kg^{-1}

At 81 DAS, the pods and haulms were separately harvested on plot basis. The pods were properly dried before they were shelled. The pod shell was quantified and bagged. The haulms were cut into bits and then appropriately shade-dried under warm air to10-12% moisture content to avoid blanching. The fodder was bagged and stored in a cool dry place before being sold. The collected data on percent dead seedlings per plot, mean root-rot index, mean of juveniles per plot, root-knot index per plot, number of juveniles per 10 g of roots, mean grains, pod shell and fodder yield (kg ha^{-1}) were subjected to costs and returns analysis and return per Naira invested was computed.

Determination of net income. The costs and returns of cowpea grains, pod shell and fodder production per hectare for each of the treatments under each field trial were calculated based on prevailing prices in 2005 and 2006. The estimated operating costs per hactare and returns of cowpea yield per kilogram used for computation under each treatment were as stated in Table I.

The Net Income (NI) for the plots under each treatment was computed using the formula:

NI = Gross revenue - Operating costs.

While the Return per Naira (R/N) invested was computed using the formula:

R/N= Gross revenue/Operating costs * 100.

RESULTS AND DISCUSSION

Net income (NI) and return per naira invested (R/N) of cowpea production in Ido field trials in 2006 and 2007. The technology that resulted in the highest NI (₦35496.67) was from the plots applied with Mycotrin® in 2006 (Table II). The treatment that produced the highest NI (₦22484.12

Table II. Costs and returns analysis of cowpea production applied with botanical and synthetic fungicides in combined 2005 and 2006 in Ido-Abuja

Treatment	Mean yield(kg ha^{-1})			Total	Revenue (₦)			Gross	Net	Return	Remark
	Grains	Pod shell	Fodder	operating cost (₦)	Grains	Pod shell	Fodder	Revenue (₦)	income (₦)	/Naira invested	
A. indica Aqueous Extract (Ai A)	469.32	252.71	3028.36	42118.40	46932.40	1263.55	9085.08	57281.03	15162.62	136	-
A. indica Ethanolic Extract (Ai E)	528.72	284.70	3257.12	52087.20	52872.40	1423.50	9771.36	64067.26	11980.06	123	-
B. perotitiana Aqueous Extract (BpA)	490.39	264.06	3523.76	42609.22	49039.60	1320.30	10571.28	60931.18	18321.96	143	HighestR/N among single extract trts.
B. perotitiana Ethanolic Extract (Bp E)	534.64	287.88	3714.17	53262.50	53464.00	1439.40	11142.51	66045.50	12783.00	124	-
Ai A + Bp A	591.76	318.64	3866.74	39445.80	59176.00	1593.20	11600.72	61929.92	22484.12	157	HighestR/N among all the extract trts.
Ai E + Bp E	610.32	328.64	3918.82	54723.18	61032.00	1643.20	11756.46	74431.66	19708.48	115	
Mycotrin®	700.84	454.65	4147.40	43486.28	70084.00	2273.25	12441.00	74798.25	31688.03	195	Highest overall R/N
No Fungus, No Extract/Mycotrin® (No F, E/M)	419.26	225.56	2023.98	34840.95	41926.00	1127.80	6071.94	49125.74	14284.79	141	-
Fungus, No E/M (Control)	231.38	154.48	1018.85	29157.43	23148.48	772.40	2317.29	26241.69	(2915.74)*	90	Net loss of 10% /Naira

- Negative net income

Table III. Costs and returns analysis of cowpea production applied with botanical and synthetic fungicides in Kwali field trials in 2005 and 2006

Treatment	Mean yield (kg ha^{-1})			Total	Revenue (₦)			Gross	Net	Return	Remark
	Grains	Pod shell	Fodder	operating cost (₦)	Grains	Pod shell	Fodder	Revenue (₦)	income (₦)	/Naira invested	
A. indica Aqueous Extract (Ai A)	517.56	278.45	3143.15	42282.50	51756.40	1392.25	9429.45	62578.10	20295.60	148	Highest R/N in the single extract
A. indica Ethanolic Extract (Ai E)	527.28	283.68	3371.74	52673.66	52728.40	1418.25	10115.22	64261.87	11588.21	122	-
B. perotitiana Aqueous Extract (BpA)	540.96	291.04	371.62	48330.04	54096.40	1455.20	11443.86	66695.46	18365.42	138	.-
B. perotitiana Ethanolic Extract (Bp E)	550.49	296.16	3828.91	56680.61	55049.20	1480.80	11486.93	68016.73	11336.12	120	-
Ai A + Bp A	599.81	322.70	3842.20	35841.35	45998.12	1613.50	11526.60	59138.22	23296.83	165	Highest R/N among all the extracts
Ai E + Bp E	619.80	333.45	3957.50	64045.89	61980.40	1667.25	11926.50	75574.14	11528.26	118	
Mycotrin®	706.50	433.90	4224.37	49996.53	70650.40	2169.50	12673.11	85493.01	35496.67	191	Highest overall R/N
No Fungus, No Extract/Mycotri® (No F, E/M)	322.87	173.90	2152.80	33982.53	42287.60	868.50	6458.4	49614.50	15631.97	146	-
Fungus , No E/M (Control)	223.98	120.50	1009.86	27395.29	22398.40	871.50	3029.58	26299.48	(1095.83)	96	Net loss of 10% /Naira

* Negative net income

ha^{-1}) among the plant extracts was from the combined aqueous extracts-applied plots. This could be attributed to synergistic bioactivity from the combined plant extracts and the cheaper cost of water than ethanol used for leaf extraction (Sinzogan *et al*., 2006). The cowpea inoculated with the rot-fungus but with no extract or Mycotrin® application had a negative net income indicating a loss (₦ 2915.74 ha^{-1}).

Net income (NI) of cowpea production in Kwali field trials in combined 2006 and 2007. In Kwali experimental field trials in 2006 and 2007, the highest mean NI (₦35496.67) was obtained from the plots applied with Mycotrin® (Table III). The mean NI from the uninoculated plots was ₦15631.96 ha^{-1}, while the lowest was observed on fungi-inoculated control plots with no pesticide application (₦1095.83 ha^{-1}). Among the plant extracts used, combined aqueous extracts of *A. indica* and *B. perotitiana* proved to be the most feasible. This might be due to synergistic bioactivity from the combined plant extracts and the cheaper cost of water than ethanol used for leaf extraction. Generally, the mean NI of the plots applied with aqueous and ethanolic extracts of *A. indica*, aqueous extract of *B. perotitiana* only and synthetic fungicides in Kwali field was higher than that of Ido. Some other registered fungicides for controlling cowpea root rot disease include Maxim, Maxim-XL, Mefenoxam, Metalaxyl, Mycostop, Ridomil-Gold and Thiram. Anita *et al.* (2004) and El-Mougy *et al.* (2006) reported specific fungicides against *R. solani* and *F. oxysporium* that cause cowpea root rot to include potassium sorbate, sodium benzoate, thiourea and acetylsalicylic acid (ASA) individually as seed soaking and/or followed by foliar spray were evaluated for their efficacy against cowpea root rot disease under greenhouse and field conditions. The treatments also resulted in the higher economic benefits and gave extra returns over that of untreated control. However, Noëlani van den Berg *et al.* (2002) found that from the evaluation of six fungicides (benomyl, bitertanol, captab captan, mancozeb, propiconazole & triforine) for reducing *Alternaria cassiae* on cowpea seed in South Africa, none of the treatments eradicated *A. cassiae* from cowpea seeds except Captab at 30 g 10 L^{-1} treatment (1.5 × the recommended rate) that proved to be effective in reducing the pathogen.

Comparative mean return per naira invested on cowpea production of botanical and synthetic fungicides on cowpea in Ido and Kwali, Abuja fields. The mean R/N of cowpea production in plots with no fungus inoculation in Ido and Kwali Abuja in 2006 and 2007 was 143.5. This indicated that it was still feasible to produce cowpea on a normal field without the application of any fungicide; since the breakeven point has been regarded as 100. The mean R/N of all the pathogen-inoculated plots with no fungicide application was less than 100 in each location. This indicated that cropping of cowpea on the field with high inocula load of *R. solani* could result in an un-profitable venture. The technology that produced the highest (R/N = 193) was from cowpea plots applied with synthetic fungicide, while it was the least from the cowpea planted in *Rhizoctonia*-borne soil without fungicide application (R/N = 93).

By considering the cost of production and returns from cowpea field under each treatment, there were relatively low NI and R/N realized from the ethanolic-extract applied plots due to the additional cost of ethanol extraction solvent but they have higher market value. Through the usage of rotary vacuum evaporator, about 60% of the ethanol used as the extraction solvent was recovered and reused for the subsequent extraction. Up to 80-85% of ethanol could be recovered from an efficient modern rotary vacuum evaporator. Water for extraction is not only more available and affordable; this could result into a higher economic benefit. Nilson *et al.* (1998) reported that the bioactivity of a given plant extract depends on the type of extraction solvent, the quality of water used the process of extraction and concentration of extracted material and its polarity.

Apart from employing costs and returns analysis method other means of economic evaluation of pesticides are by marginal analysis for variable costs and net benefits, partial budget and by dominance analysis (Sinzogan *et al.*, 2006; Okoye *et al*., 2007). Marginal analysis is the process of calculating marginal rate of return between treatments, proceeding in steps from a lower cost treatment to that of next higher cost and the comparing those rates of return to the minimum rate of return acceptable to farmers. The purpose of marginal analysis is to reveal just how the net benefits from an investment increase as the amount invested increases. Partial budget estimates from the net benefits and variable costs for each pesticide used in the experiment, while a dominance analysis is carried out by first listing the treatments in order of increasing costs that vary. Any treatment that has net benefits that are less than or equal to those of a treatment with lower costs that vary is dominated (Adekeye & Ditto, 1995; Dutoit, 1999).

CONCLUSION

Other economic analysis methods such as combined use of crude aqueous or ethanolic extracts of *A. indica* and *B. perotitiana* leaves were found to be the most feasible next to the use of Mycotrin®. The production of ethanolic leaf extracts was more expensive than aqueous leaf extract as it was indicated by the net income. A well prepared crude plant extract will be easier for the resource-poor farmers to afford and renew. Such application might be used as an effective and safe technique for controlling soil-borne plant pathogens in addition to avoid environmental pollution due to decrease the usage of chemical fungicides. Inclusion of botanical fungicide such as the combined neem and iron weed leaves extracts into the integrated disease management (IDM) is recommended.

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