Using Wood Vinegar to Promote Sustainable Cowpea Production in Northern Ghana

Edwin K. Akley[1] and Barbara K. Arthur[2]

[1] CSIR-Savanna Agricultural Research Institute, Nyankpala, Ghana P. O. Box TL 52, Tamale

[2] University for Development Studies, P. O. Box TL 1350, Tamale, Ghana

Introduction

- Organic farming aid (OFA), also called wood vinegar (WV), is a product of pyroligneous acid (PA) that can produce significant economic and environmental benefits when applied correctly.
  - ✓ Improved photosynthetic performance and growth of lettuces were observed when 0.2% diluted chestnut PA was applied using foliar application (Vannini et al., 2021).
  - ✓ However, information on effective methods of applying WV to enhance crop productivity is limited in Ghana's cropping systems.
- At present, no attempt has been made to investigate the efficacy of OFA (i.e. wood vinegar) application methods in crop production, limiting the development of wood vinegar technology in enhancing plant productivity and restoring soil health in Ghana's cropping systems.

Objectives

1. Evaluate the impacts of different methods of WV application on cowpea growth and yield
2. Analyze the cost-benefit ratio of the different methods of WV application in cowpea production.

Methods

Location: Nyankpala, Ghana

Soil Type: Ferric Luvisols (FAO classification)

Baseline Soil Property:

- ✓ Sandy loam
- ✓ Available P = 2.78 mg/Kg
- ✓ Available N (NH_4^+-N + NO_3-N) = 0.21 mg/Kg
- ✓ Soil pH (soil:water;1:5) = 5.7

Management history: Soybean-Maize-Fallow-Cowpea

Experimental Design: RCB with four replications.

Treatments: Four methods of WV application (concentration =1:500 or 45 mL WV in 22.5 L water);

- ✓ Control
- ✓ Foliar application
- ✓ Soil drenching (SD)
- ✓ SD + Foliar application

Test Crop: Cowpea (*Vigna unguiculata* var Wang-kae and Padituya)

Spacing: Sowed at an inter-row (ridge) and intra-plant distance of 60x20 cm, respectively.

OFA Application:

- First WV treatment was imposed 24 days after planting (DAP), corresponding to the V4 stage.
- Subsequently, the WV was applied weekly (7 days)
- Sampling time; V4 (4-leaf), V8 (8-leaf), R2 (full flower) & R4 (full pod) stages

Data Collection

Biomass dry matter (shoot and root dry matter); Nodulation (nodule number and nodule mass); Yield component (pod load and pod yield); Yield (grain yield and stover yield), and Economic analysis

Statistical Analysis

- Data were subjected to analysis of variance using proc-mixed model in SAS at an α-level of 0.05.
- Means were separated using Tukey-Kramer pairwise comparison test

Results

- Shoot dry matter for Wang-kae was significantly affected ($p < 0.001$) after WV application. SD yielded greater shoot dry matter than Foliar application and Combined SD+Foliar application of WV (Table 1).
- However, root dry matter, nodule number and nodule mass of Wang-kae were significantly improved by WV application (Table 1).
- With Padituya, application of WV did not enhance shoot dry matter, root dry matter, nodule number and nodule mass (Table 1)

Table 1: Effect of WV application methods on Dry matter (DM) and Nodulation

Treatments	Shoot DM (g/Plant)	Root DM (g/Plant)	Nodule Number (g/Plant)	Nodule mass (mg/Plant)
Variety: Wang-kae				
Control	5.64 b	0.51 a	10 a	71.2 ab
Foliar appl.	7.98 ab	0.63 a	10 a	81.1 a
SD	9.17 a	0.60 a	10 a	84.0 a
SD+Foliar appl.	6.12 b	0.51 a	11 a	62.9 b
Variety: Padituya				
Control	8.90 a	0.694 a	17.8 a	65.8 a
Foliar appl.	8.03 a	0.718 a	17.7 a	64.4 a
SD	8.72 a	0.662 a	17.5 a	59.3 a
SD+Foliar appl.	7.73 a	0.670 a	15.3 a	64.5 a

Values in columns, followed by the same small letter, are not significantly different (p<0.05) using the Tukey-Kramer post hoc test.

Table 2: Effect of WV application methods on Grain Yield and Stover Dry Matter (DM)

Treatments	Wang-kae	Padituya	Wang-kae	Padituya
	Grain yield (Kg/Ha)		Stover yield (Kg/Ha)	
Control	873 c	1083 a	697 b	1770 b
Foliar appl.	1120 b	1116 a	1674 a	2032 a
SD	1265 a	1080 a	1369 a	2038 a
SD+Foliar appl.	854 c	906 b	1321 a	2878 a

Values in columns, followed by the same small letter, are not significantly different (p< 0.05) using the Turkey-Kramer post hoc test.

- Application of WV significantly affected the grain and stover yield of both cowpea varieties (Table 2).
- SD of WV for Wang-kae produced the highest grain yield compared to the other treatments. Also, the Combined SD+Foliar application of WV is comparable to that of the Control (Table 2).
- For Padituya, the control, foliar application of WV and Soil Drenching of WV produced higher grain yield than the combined SD+Foliar application of WV (Table 2).
- Application of WV significantly affected the stover yield of Wang-kae and Padituya. In Wang-kae, the application of WV improved stover yield over the control.
- Likewise, in Padituya SD+Foliar, WV application stimulated a higher stover yield than the other treatments (Table 2).

Results

Figure 1: Photos of the field

Tab 3: Economic analysis on WV application

Treatments	Adjusted Grain yield (Kg/Ha)	Percent Increase (%)	Gross Revenue (USD)	Total Cost (USD)	Net Returns (USD)	BCR
Variety: Wang-kae						
Control	785		978	425	553	1.30
Foliar appl.	1008	28	1,255	453	802	1.77
SD	1139	45	1,418	465	953	2.05
SD+Foliar appl.	768	-2	956	473	484	1.02
Variety: Padituya						
Control	974		1,213	425	788	1.86
Foliar appl.	1005	3.1	1,251	453	798	1.76
SD	972	-0.3	1,210	465	745	1.60
SD+Foliar appl.	816	-16.3	1,015	473	543	1.15

- The application of WV affected revenue generated by Wang-kae and Padituya (Table 3). BCR of Wangkae and Padituya is greater than 1.
- In Wangkae, SD of WV generated the highest returns. The increased order of BCR in Wang-kae is as follows: SD > Foliar application > Control > SD+Foliar Application (Table 3).
- In Padituya, the control generated the greatest returns. The order of increased BCR is Control > Foliar application > SD > SD+Foliar Application (Table 3).

Conclusion

- Soil drenching and foliar application are the most effective methods of applying WV to achieve greater Wang-kae yield. Wang-kae cowpea producers who use either soil drenching or foliar application would get greater profits or returns on investment
- With Padituya, the control treatment economically generated the greatest returns on investments, suggesting that WV application in Padituya would not yield returns on investments.
- Apart from economic gain due to improved grain yield by WV application, cowpea producers would benefit from improved stover yield, an excellent fodder for farm animals.

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