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Research Application Summary

Improving resilience of rural women to climate change in Western Sudan

Mohammed, A. A. H.,[1] Muna, A.[2] & Elshiekh, A. I.[3]
[1] Dept. of Rural Extension and Training, University of Kordofan, P.O. Box 160, Elobeid, Sudan
[2] Institute of Environmental Studies, University of Khartoum, P.O. Box 321, Khartoum, Sudan
[3] Dept. of Crops Science, University of Kordofan, P.O. Box 160, Elobeid, Sudan
Corresponding Author: abugitaf2013@gmail.com

Abstract

Home gardening is wide spread amongst rural women in western Sudan under rainfed conditions. However, due to climatic variability that affects both soil fertility and rainfall patterns, garden yields are often drastically reduced, affecting family food security in sudan. This study was initiated to enhance garden yield by provision of both water and fertilizer using biogas liquid effluent obtained through biogas units installed in rural households. Although only 15 units were installed, 50 households benefited from the biogas effluent. Two types of vegetables, Okra *(Abelmoschus esculentus* L. Moench) and Jew mallow (*Corchorus olitorius* L.) were randomly planted in plots and subplots prepared for the application at different concentration (0.5 m^3, 1 m^3, and 1.5 m^3) of biogas effluent. MSTATC and STATISTIX8 program were used for data analysis. Results showed significant increase in yields for both vegetables in the off season, except Jews mallow in the first season. Okra yields increased from 0.93 t/ha fresh green pods to 1.4 t/ha with 1.5 m^3 fertilizer in season one. In season two, okra yield increased from 0.92 t/ha to 1.38 t/ha with 1.5 m^3 fertilizer application. In season two, Jew's mallow yield increased from 13.15 t/ha to 21.06 t/ha with 1.5 m^3 fertilizer application. Combined analysis of variance indicated that there were significant differences among treatments for all studied traits in two seasons. The highest effluent concentration (1.5m^3) gave the best yield for both types of vegetables.

Key words: Biogas effluent, food security, Sudan, women's resilience

Résumé

Le jardinage de case est une pratique très répandue chez les femmes rurales à l'ouest du Soudan en régime pluvial. Cependant, en raison de la variabilité climatique qui affecte à la fois la fertilité du sol et les précipitations, les rendements des jardins sont souvent réduits de façon drastique, ce qui affecte la sécurité alimentaire des familles au Soudan. Cette étude a été entreprise pour améliorer le rendement des jardins en fournissant de l'eau et des engrais issus des effluents liquides de biogaz des unités de biogaz installées dans les ménages ruraux. Bien que seulement 15 unités aient été installées, 50 ménages ont bénéficié d'effluent du biogaz. Deux types de légumes, le gombo (Abelmoschus esculentus L. Moench) et la mauve juive (Corchorus olitorius L.) ont été plantés au hasard dans des parcelles et sous-parcelles préparées pour l'application à différentes concentrations (0,5 m3, 1 m3 et 1,5 m3) d'effluent de biogaz. MSTATC et STATISTIX8 ont été utilisés pour l'analyse des données.

Les résultats ont montré une augmentation significative des rendements des deux légumes pendant la contre-saison, à l'exception de la mauve juive pendant la première saison. Les rendements de gombo sont passés de 0,93 t / ha de fruits vertes fraîches à 1,4 t / ha avec 1,5 m3 d'engrais dans la première saison. Dans la deuxième saison, le rendement du gombo a augmenté de 0,92 t / ha à 1,38 t / ha avec une application d'engrais de 1,5 m3. Au cours de la deuxième saison, le rendement de la mauve juive est passé de 13,15 t / ha à 21,06 t / ha avec une application d'engrais de 1,5 m3. L'analyse de la variance combinée indiquait qu'il existait des différences significatives entre les traitements pour tous les caractères étudiés au cours des deux saisons. La plus forte concentration d'effluents (1,5m3) a donné le meilleur rendement pour les deux types de légumes.

Mots clés: Effluents de biogaz, sécurité alimentaire, Soudan, résilience des femmes

Background

Seasonal changes in previous years in Sudan have had devastating effects on agricultural production. In particular, women farmers have been affected. Rural women have prioritized home gardening as an alternative source to bridge the gap as weather patterns and rainfall have become unpredictable. Home gardening is usually characterized as subsistence-oriented whereas open space farming tends to be perceived as market-focused (Moore-gough *et al.,* 2007). The vegetables garden has traditionally been located in an area separate from other parts of the landscape because it was considered unsightly. Okra (*Abelmoschus esculentus* L. Moench) and Jews mallow (*Corchorus olitorius* L.) are important and preferred vegetables in western Sudan due to high consumption for rural household either fresh or dried. Successful production of vegetables rely on rainfall, varieties cultivated and seed supply.

The purpose of vegetables production varies from large-scale farm enterprises to private home gardening, where vegetables are essential elements to supplement diets and income (Ahmad *et al*., 2007). For vegetable growth, a uniform supply of nutrients is needed throughout the season (Anon, 2014). Okra is said to have originated in Asia and Africa, and can be established by sowing seeds directly into the garden. Harvesting is 60 to 70 days after planting (Westerfield, 2008). Global okra cultivation covers an area of 0.78 million ha from which an output of about 4.99 million MT with average annual yield of 6.39 t/ha. Besides consumption of fresh pods boiled, its dried form is used as soup thickener or in stew. The green fruits are rich sources of vitamins, calcium, potassium and other minerals (Engineering, 2013). The origin of Jew's mallow is unknown, but it has reportedly been cultivated for centuries, both in Asia and Africa, and is planted either by direct seeding or transplanting (Department of Agriculture, 2012). Jew mallow is a very popular leafy vegetable in Kordfan. It is very nutritious, rich in beta-carotene, iron, protein, calcium, thiamin, riboflavin, niacin, vitamin C and E and dietary fiber (Gardeners, 2010). Growth of both vegetables is constrained by unpredictable rainfall patterns in Sudan, and other sources of moisture and nutrients need to be explored. This study sought to evaluate the effect of biogass effluent concentration on growth of the two vegetables in home gardens in western Sudan.

Study Description

The study area was undertaken in west Kordofan State of Sudan. West Kordofan State is located in the western part of Sudan, and falls in the transition belt between war-effected south and the drought affected north (UN, 2003; Dietrich, 2008) located within latitudes 12° 0′ N, and longitudes 28° 9′ E. The State borders North Kordofan, South Kordofan, East Darfur, North Darfur and South Darfur (Awad e*t al.,* 2010). The total area covered is estimated to be 111,373 square km^2 (UN, 2003), extending from low rainfall savanna to high rainfall and hill catena and varied vegetation (Eltahir *et al*., 2015).

Field experiments were conducted for two successive seasons on women's home gardens. The piece of land allocated for vegetables plantation was divided into 12 plots of 2m x 1m x 0.15 each. Each plot was cultivated with two different types of vegetables each replicated in four subplots and four treatments. The 12 plots were randomly allocated to four effluent treatments; high ($1.5m^3$/ha), medium ($1m^3$/ha), low ($0.5m^3$/ha) and control of biogas byproduct. The experiement was laid out in a Randomised Completely Block Design (RCBD). Data were analyzed using Statistix8 program and MSTATC for ANOVA and comparison of seasons.

Results and Discussion

The variations in okra productivity in the four treatments are shown in Table 1. Harvesting of Okra began 59 days after planting. Okra yielded 0.93 t/ha after planting without adding liquid fertilizer and increased to 0.98 t/ha, 1.31 t/ha, 140 t/ha at $0.5m^3$,$1m^3$, and $1.5m^3$ in Season 1, respectively. In Season 2, yields were 0.92 t/ha, 0.95 t/ha, 1.26 t/ha, and 1.38 t/ha for control, $0.5m^3$,$1m^3$, and 1.5m,^{3} respectively. Pests and diseases during vegetative growth led to decline in yield in Season 2 and this was exacerbated by low rainfall patterns. For both seasons there were significant differences in yield as Okra responded positively to biogas liquid fertilizer application. This is in agreement with findings reported by Ibarrarán *et al.* (2010) and Engineering (2013). Results revealed that there were no significant differences in green pod length accross four treatments and across two seasons (P-value ≥0.07 and 0.1, respectively). Plant height were similar across the 1st and 2nd seasons (P-value ≥ 0.28 and 0.34 for seasons 1 and 2, respectively). Results of combined analysis to investigate the differences between the two seasons are presented in Table 2. There were significant differences between seasons especially in number of fruits per plant. The results suggest that okra yields in the area can be increased with high application of liquid fertilizer during dry and off-seasons. Hence, to ensure optimum yield of okra especially in dry areas and during off-seasons, high doses of biogas liquid fertilizer application should be used.

Jew's mallow produced 14.1 t/ha (Table 3) without adding liquid fertilizer but yields declined to 13.9 t/ha by adding $0.5m^3$ and increased to 17.4 t/ha and 21.6 t/ha under $1m^3$, and $1.5m^3$ effluent in season 1, respectively. There were no significant deferences between the yields in season 1 while in season 2 there were significant differences (p-value ≤ 0.02). There were also significant differences in plant heights in season one (p-value ≤ 0.03). In season 2 similar resullts were observed. Variations in heights, i.e., 51cm, 48cm, 58cm, and 63cm for control, $0.5m^3$, $1m^3$, and $1.5m$,^{3} respectively were observed. Similar results have been reported by Rajesh *et al.* (2014). Leaf surface area of the crop under high amount of liquid fertilizer (Treatment 4) was highest when compared with both medium (Treatment 3), low liquid fertilizer (Treatment 2), and without liquid fertilizer (Treatment 1), respectively. Jew's mallow responds well to added fertilizer, especially nitrogen (Department of Agriculture, 2012).

The purpose of vegetable production varies from large-scale farm enterprises to private home gardening, where vegetables are essential elements to supplement their diets and income (Ahmad *et al.,* 2007). The present results show that use of biogas liquid effluent could enhance production of Okra and Jew mallow in Western Sudan.

Table 1: Results of okra productivity for two seasons in the study area

Treatment effluent	Fruit fresh weight (t/ha)		Fruit length (cm)		Plant height (cm)		No. of fruits per plant	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
0 m^3	0.93	0.92	5.33	5.33	66.67	64.3	1.02	1.02
0.5m^3	0.98	0.95	6.33	5.67	66.33	68.00	1.25	1.25
1m^3	1.31	1.26	9.00	8.00	74.33	71.00	1.88	1.48
1.5m^3	1.40	1.38	7.67	8.33	83.33	80.33	2.06	1.95
Mean	1.16	1.13	7.08	6.83	72.67	70.92	1.55	1.43
P-value	0.05	0.04	0.07	0.11	0.28	0.34	0.05	0.21
±SE	0.11	0.09	0.79	0.88	5.47	5.84	0.23	0.28
LSD 5%	0.37	0.34	-	-	-	-	0.79	-
CV%	15.84	15.27	19.40	22.22	13.05	14.27	25.47	33.61

*P ≤ 0.05, ** P ≤ 0.01, *** P ≤ 0.001

Table 2: Yield of Okra as influenced by interaction effects of seasons and fertilizer treaments productivity

Factors		Fruit fresh weight (t/ha)	Fruit length (cm)	Number of fruits/plant	Plant height (cm)
Seasons	1st season	1.158	7.083	2	72.667
	2nd season	1.127	6.833	1	70.917
Treatments	Control	0.925	5.333	1	65.500
	1000 ml	0.964	6.000	1	67.167
	2000 ml	1.285	7.833	2	72.667
	3000 ml	1.394	7.833	2	81.833
Season × treatment	Season 1 x Control	0.935	5.333	1	66.667
	Season 1 x $0.5m^3$	0.984	6.333	1	66.333
	Season 1 x $1m^3$	1.307	7.667	2	74.333
	Season 1 x $1.5m^3$	1.405	9.000	2	83.333
	Season 2 x Control	0.915	5.333	1	64.333
	Season 2 x $0.5m^3$	0.945	5.667	1	68.000
	Season 2 x $1m^3$	1.264	8.000	1	71.000
	Season 2 x $1.5m^3$	1.383	8.333	2	80.333
F value		0.53	0.22	1.63	0.27
P value	Treatment Seasons	0.001 -	0.0 1 -	0.01	0.05 -

*P ≤ 0.05, ** P ≤ 0.01, *** P ≤ 0.001

Table 3. Yields of Jews mallow for two seasons in the study area

Treatment	Fruit fresh weight (ton/ha)		Plant height (cm)		Number of leafs per plant		Leaf surface area (cm)	
	Season1	Season2	Season1	Season2	Season1	Season2	Season1	Season2
0 m³	14.11	13.15	53.00	51.00	18.67	20.00	3.567	3.267
0.5m³	13.89	12.85	51.33	47.67	18.33	18.67	3.967	3.567
1m³	17.37	15.57	57.00	57.67	20.00	22.33	4.767	3.733
1.5m³	21.62	21.06	62.67	62.67	25.33	23.67	4.067	4.300
Mean	16.75	15.66	56.00	54.75	20.58	21.17	4.092	3.717
P-value	0.064	0.024*	0.025*	0.038*	0.058*	0.229	0.003**	0.019*
±SE	1.766	1.472	1.969	2.872	1.552	1.630	0.121	0.159
LSD 5%	-	5.095	6.816	9.939	-	-	0.419	0.552
CV%	18.27	16.29	6.09	9.09	13.06	13.34	5.14	7.44

*P ≤ 0.05, ** P ≤ 0.01, *** P ≤ 0.001

Table 4: Yield of Jews mallow as affected by season and fertilizer interaction

Factors		Fresh weight (t/ha)		Leave area (cm)		Number of L/p		Plant height (cm)
Seasons	1st season	16.745		4.092		21		56.000
	2nd season	15.657		3.717		21		54.750
Treatments	Control	13.627		3.417		19		52.000
	1000 ml	13.369		3.767		19		49.500
	2000 ml	16.468		3.900		21		57.333
	3000 ml	21.341		4.533		24		62.667
Season ×	Season1 x Control	14.108		3.567		19		53.000
treatment	Season1 x 0.5m3	13.890		3.967		18		51.333
	Season1 x 1m3	17.367		4.067		20		57.000
	Season1 x 1.5m3	21.617		4.767		25		62.667
	Season2 x Control	13.145		3.267		20		51.000
	Season2 x 0.5m3	12.848		3.567		19		47.667
	Season2 x 1m3	15.570		3.733		22		57.667
	Season2 x 1.5m3	21.064		4.300		24		62.667
F value		0.144		2.029		0.104		0.026
P value	treatment seasons	0.001	-	0.00	0.23	0.012	-	0.001 -

$*P \leq 0.05$, $** P \leq 0.01$, $*** P \leq 0.001$

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