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Improving women garden for enhancing resilience to climate change in western Sudan

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ABSTRACT

Consequence effects of climate variability in Sudan make home garden widespread practice to fill the competitive demand of Household consumption. The overall objective of the research is to improve the productivity of home gardens owned and managed by poor women in rural rain-fed semi-arid areas of Sudan adversely affected by climate change. The area of study is located in some villages of western Sudan where biogas units were installed in some households. The effluent of biogas units were used as organic fertilizer in women garden. The area allocated for each garden was divided into plots and subplots (as replicates) for application of different concentration of the fertilizer. Two types of vegetables were cultivated randomly, these were Okra" Abelmoschus esculentus L. Moench" and Jew mallow" Corchorus olitorius L." as preferred by the women. The experiment covered two seasons. Applied fertilizer concentrations were 0 m^3, 0.5 m^3, 1 m^3, and 1.5 m^3 per hectare. MSTATC and STATISTIX8 program were used for data analysis. Results showed significant increase in yields for both vegetables, except Jews mallow in the first season. Okra yield increased from 0.93 ton/ha fresh green pods to 1.4 ton/ha with 1.5 m^3 fertilizer in season one. In season two, okra increased from 0.92 ton/ha to 1.38 ton/h with 1.5 m^3 fertilizer application. In season two, Jew's mallow yield increased from 13.15 ton/ha to 21.06 ton/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 Okra and Jews mallow. The study insure optimum yield of Okra and Jew mallow area during off-season and high dose from biogas byproduct is recommended.

Key words: *climate change, enhancing resilience, food security, women garden, Sudan*

Background

Seasons changed in previous years in the area had direct effects on agricultural production; in particular for those women depend on crops for survive. Vast rural women emphasize on home garden as alternative source to bridge these gap. Home gardening is usually characterized as mainly subsistence-oriented 'place of farming', whereas open space farming tends to be perceived as market-focused (Moore-gough, Specialist, and Gough 2007) The vegetables garden has traditionally been located in an area separate from other parts of the landscape because it was considered unsightly (Science 2013). Okra (Abelmoschus esculentus L. Moench) and Jews mallow (Corchorus olitorius L.) represent most preferable vegetables in western Sudan due to special consumption for rural household either fresh or dried. Successful production of vegetables relay on the local climate and season, varieties cultivated and supply of satisfactory seeds. The purpose of vegetables 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). Vegetables to produce lush, continuous growth throughout the season, they need a uniform supply of nutrients (Anon 2014). Okra; the crop is said to have originated in Asia and Africa, can be established by sowing seeds directly into the garden o harvest about 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 and average yield of 6.39t/ha are obtained yearly. Besides the consumption of the fresh pods as boiled vegetable, 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, is planted either by direct seeding or transplanting (Department of Agriculture 2012) is a very popular leafy vegetable in Kordfan, Leaves are alternate, simple, 5 to 15 cm long and very nutritious, rich in beta-carotene, iron, protein, calcium, thiamin, riboflavin, niacin, vitamin C and E and dietary fiber (Gardeners 2010).

Objectives

Due to wide preference of some vegetables crops such as Okra and Jews mallow the study is seek to produce advices regarding using biogas effluent in home garden to improve women resilience to bridge the gap of seasonal variability.

Study Description

The geographical interest of the study area is laid on semi-arid region in Sudan (Dietrich Darr 2008). West Kordofan State is located in the western part of Sudan, and falls in transition belt between war-effected in the south and the drought affected in the north(UN 2003) 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 et al. 2010) figure (1). The total area covered is estimate to be 111,373 square km^2 (UN 2003), extending from low rainfall savanna to high rainfall and hill catena and its vegetation varies greatly (Eltahir et al. 2015).

Due to seasonal variability and failed of corps yield in last ten year vast majority of rural people in area engage in varying degree of backyard crop production as trying to bridge the gap of climate change. Resent study indicated that climate change is likely to reduce agricultural productivity; production stability and income in some area that already have high level of food insecurity (Hassan, 2000).

The field experiment will be conducted for two successive seasons working with women gardens. The piece of land allocated for vegetables plantation will be divided into 12 plots of 2 m x 1 m x 0.15 each. Each plot will be cultivated with two different types of vegetables each replicated in 4 subplots and 4 treatments. Okra direct seed beds with spacing 0.25mx0.60m in soil, while Jews mallow will interspersing to the plot. The 12 plots will be randomly allocated to four treatments, high (3000ml), medium (2000ml), little (1000ml) and control of biogas byproduct using Randomise Completely Block Design (RCBD). The obtained data for two successful seasons were analyzed using Statistix8 program and MSTATC for comparison between seasons.

Results

The results depicted that Okra was produced fresh green pods about 0.93 ton/ha after planting without adding liquid fertilizer and rose to 0.98 ton/ha, 1.31 t/ha, 140 ton/ha when adding 0 $m^{3,}$ 0,5m^3, lm^3, and 1.5m^3 in season one respectively. In season two declined gradually to 0.92 ton/ha, 0.95 ton/ha, 1.26 ton/ha, and 1.38 ton/h at 0 $m^{3,}$ 0,5m^3, lm^3, and 1.5m^3 respectively, there were no significant differences between green pods length in four treatments used in two seasons, no significant between heights of plant in season1 and season2, variations of pods in each plant was significant in season1 and not significant in season2. Results of combined analysis revealed that there are significant differences between (treatments); control, 0,5m^3, lm^3, and 1.5m^3respectively.

The results of Jews mallow showed that here were no significant differences between the weights in season1, and here were significant differences between the weights in season2, results also showed that there were significant differences between plant heights in season1 and in season2. In addition results indicated that there were not significant differences between numbers of leaf per plant for both season. There were significant differences between Leaf surface areas for both seasons

Results of combined analysis revealed that there were significant differences between (treatments); control, 0.5m^3, 1m^3, and 1.5m^3 respectively, and significant differences between leaf areas for seasons studied.

Discussion

The variations of okra productivity in the four treatments are shown in Table (1). Harvesting of Okra actually began at about 59 days after planting. Okra was produced fresh green pods about 0.93 ton/ha after planting without adding liquid fertilizer and rose to 0.98 ton/ha, 1.31 t/ha, 140 ton/ha when adding 0.5m^3,1m^3, and 1.5m^3 in season1 respectively. In season2 declined gradually to 0.92 ton/ha, 0.95 ton/ha, 1.26 ton/ha, and 1.38 ton/h at control, control, 0.5m^3,1m^3, and 1.5m^3 respectively. Pests and disease deficit during vegetative growth leads to decline in yield in season2, this happen due to climate change effects in the area, pest out brake consider climate change events(Ibarrarán, Malone, and Brenkert 2010) . For both season there were significant differences in yield and this result showing that okra responds positively to biogas liquid fertilizer application. This is in agreement with the findings of who reported increased yield of okra with increasing fertilizer application (Engineering 2013). The second measurement used in experiment is pods length. Also Results revealed that there were no significant differences between green pods length in four treatments used in two seasons (P-value ≥0.07 and 0.11 respectively).

Furthermore results depicted that there were not significant differences between heights of plant in experiment. Similar scenario was also observed during the second season (P-value ≥ 028 and 0.34 for two seasons respectively). The fourth measurement used is number of green pods per plant. Yield responses of plant pods in plot to the four different treatments during the 2014 season and season 2015 and variations of pods in each plant was significant in season one and not significant in season2, (P-value ≤ 0.05 for season1 and 0.21 for season2). Some of the measurements used also reported negative growth; Theses represent mainly unconsumed parts by local communities in the area and has not vital effects in total productivity. The results mentioned showed that okra yield 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 from biogas liquid fertilizer application is recommended.

Results of Combine analysis to investigate the differences between two seasons in table (2) indicated that there are significant differences between seasons regarding number of fruit per plant, for seasons studied. Also results extend to indicate that there were significant differences between (treatments); control, $0.5m^3$,$1m^3$, and $1.5m^3$ respectively, for seasons studied.

Jew's mallow is a very popular leafy eatables vegetable in the northern and eastern of Kordofan region. Harvesting of Jew's mallow actually began at about 30 - 60 days after planting. Results in table (3) revealed that Jew's mallow produced about 14.1 ton/ha after planting without adding liquid fertilizer and declined to 13.9 ton/h by adding $0.5m^3$ and raised to 17.4 ton/ha and 21.6 ton/ha when adding $1m^3$, and $1.5m^3$ in season1 respectively this mean there were not significant deference between the weights in S1 while In season2 there were significant differences between the weights at control, $0.5m^3$,$1m^3$, and $1.5m^3$ (p-value ≤ 0.02) table (3) also there were significant differences between plant heights at control, $0.5m^3$,$1m^3$, and $1.5m^3$ respectively in season one (p-value ≤ 0.03), in season2 similar consequences was happen when we used alike treatments. Variations of heights are about 51cm, 48cm, 58cm, and 63cm at control, $0.5m^3$, $1m^3$, and $1.5m^3$ respectively. Similar results have been reported in the literature (Rajesh et al. 2014) , at same table showed not significant differences between numbers of leafs per plant at control, $0.5m^3$,$1m^3$, and $1.5m^3$ with general mean 21 leave per plant for both season. 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 in season1 and season2 (p-value ≤ 0.003 for S1 and ≤ 0.01 for season2). Jew's mallow responds well to added fertilizer, especially nitrogen, Fresh leaves are essential parts (Department of Agriculture 2012). Measurements of yield response of crops to the applied fertilizer can be a way to determine crop consumption for human being in life systems. Results of Combine analysis to investigate the differences between two seasons table (4) indicated that there were significant differences between measurement leaf areas for seasons studied. Also results extend to revealed that there were significant differences between (treatments); control, $0.5m^3$,$1m^3$, and $1.5m^3$ respectively. 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).

Table 1. Results of okra production for two seasons in the study area

Treatment	Fruit fresh weight (ton/ha)		Fruit length (cm)		Plant Height (cm)		No. of Fruits per plant	
	Season1	Season2	Season1	Season2	Season1	Season2	Season1	Season2
$0\ m^3$	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 Significant, indicating by Statistix8: source; field research (2016)

Table 2. Combine analysis of season, treatment and interaction of season vs. treatment on Okra production

		Fruit fresh weight (t/ha)	Fruit length (cm)	Number of fruits/plant	Plant height (cm)
Seasons	1^{st} season	1.158	7.083	2	72.667
	2^{nd} 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	Season1 x Control	0.935	5.333	1	66.667
	Season1 x $0.5m^3$	0.984	6.333	1	66.333
	Season1 x $1m^3$	1.307	7.667	2	74.333
	Season1 x $1.5m^3$	1.405	9.000	2	83.333
	Season2 x Control	0.915	5.333	1	64.333
	Season2 x $0.5m^3$	0.945	5.667	1	68.000
	Season2 x $1m^3$	1.264	8.000	1	71.000
	Season2 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 -	0.01 -	0.01 0.27*	0.05 -

P ≤ 0.05 Significant, indicating by MSTATC, Combine analysis, source; field research (2016)

Table 3. Results of Jews mallow production 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
$0\ m^3$	14.11	13.15	53.00	51.00	18.67	20.00	3.567	3.267
$0.5m^3$	13.89	12.85	51.33	47.67	18.33	18.67	3.967	3.567
$1m^3$	17.37	15.57	57.00	57.67	20.00	22.33	4.767	3.733
$1.5m^3$	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 Significant, indicating by Statistix8, source; field research (2016)

Table 4. Combine analysis of season, treatment and interaction of season vs. treatment on production of Jews mallow

		fresh weight (t/ha)	Leave area (cm)	Number of L/p	Plant height (cm)
Seasons	1^{st} season	16.745	4.092	21	56.000
	2^{nd} 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 × treatment	Season1 x Control	14.108	3.567	19	53.000
	Season1 x $0.5m^3$	13.890	3.967	18	51.333
	Season1 x $1m^3$	17.367	4.067	20	57.000
	Season1 x $1.5m^3$	21.617	4.767	25	62.667
	Season2 x Control	13.145	3.267	20	51.000
	Season2 x $0.5m^3$	12.848	3.567	19	47.667
	Season2 x $1m^3$	15.570	3.733	22	57.667
	Season2 x $1.5m^3$	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 ≤ 0.05 Significant, indicating by MSTATC, Combine analysis, source; field research (2016)

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