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Organic Agriculture using Sack and Deck Farm Approach

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Abstract*: *The present study aimed at analysis of a sustainable technique of framing, thus economizing the land area through management of space, and also increasing the farming output, improved management of water, and linkage of organic farming techniques aiming at sustainability. These technologies include Sackfarm and the Deckfarm systems. This involves the production of organic compost, biofertilizer, and organic pest and disease control system that are combined in order to solve the issues relating to crop nutrient thus increase the productivity. The use of plants residues in this study for the compost integration cleaned up the filth on the farm. This work investigated the possibility of organic farming with a drip irrigation system that improves water use efficiency of crop production without using any chemical fertilizers. The Sack and Deck farm aims at reducing the food related diseases, poverty and effective water management taking into account the fast disappearance of forest cover and increasing carbon emission.

Index Terms*: *Poverty reduction, Organic production, Sackfarm, Deckfarm, drip irrigation, compost, biofertilizer.

I. INTRODUCTION

A. Background and research problem

There has been an increasing issue of starvation deaths, diseases and poverty due to lack of awareness among the farmers regarding the technological advancements. Thus, it calls for better inputs into agricultural advancements that have a sustainable approach [1]. This is done through an integrated crop and animal husbandry and modern and natural environment. There is increase in population [2] and thereby higher demand for food. The use of Agro-chemicals for Crop Production and the decline in health has necessitated this all important agriculture approach of Sack and Deck farming practices as an alternative by using low cost technologies (Sack and Deck farming, low cost Polyvinyl Chloride - PVC) [3].

Sack farm and deck farm system ensures space management, soil management; high quality production with low cost, cost and profit analysis is easily calculated before investment. It is obvious that a sack farm can take 30 cabbages while in its actual position on the ground can take only one cabbage. Drip irrigation system keeps the system running without any interruption and the biofertilizer is used for the fertilization of farm crops [4]. These systems continue to repeat themselves with prudent management principles. The primary goal of this study is to ensure organic food security and protect the environment and human life. Specifically to meet the nutritional needs of the world and to make farming accessible to places that are inaccessible in order to promote business agriculture in a more advanced manner. Again, this study was conducted to ensure effective use of water for irrigation under the drip system and saw the need in organic farming practices to safe guide the environment and safe cost involved in chemical fertilizers [5].

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B. Project details

Sackfarm: Sack farm is a system of farming whereby sacks that were formally used for storing food is now used for farming by filling it up with compost. Example includes, the white long fertilizer sack [6]. A well prepared soil such as compost (biofertilizer), biochar and fertisoil or compost fertilizer is used in ratio terms with soil for the sack installation. A PVC pipe of (4" or 5") is used to pass through the sack into the ground and a well prepared compost is then filled into the sack. Holes are now opened around the sack from top to down for either sowing or transplanting. The PVC pipes (4" or 5") also contains water exit holes that have the capacity to water crops straight to the roots and keep the sack moisturized for 7 days or more before watering again. This technology ensures efficient water management and usage. The PVC pipe (1") which is then connected to the reservoir supplies water to the main pipe. Water is then mixed with nutrients and supply to crops and these nutrients are then stored by our biochar [7].

Deckfarm: The deck farm is designed for vegetable tubers such as carrots, onions, ginger, garlic, etc. It has different capacity holdings depending on the root vegetable. The study Deckfarm was 25 x 1 x 3 meters in length, width and height. This to produced 30,000 root carrots. The deckfarm had the capacity of producing in abundance, managed water and space just like the sackfarm. The deckfarm also gave the study the opportunity to calculate the initial investment and returns before embarking on such ventures.

Deckfarm capacity analysis (carrot analysis)

Deckfarm analysis taken as 25L x 1W x 3H meters. However, 25L = 300, 1W = 10 and 3H = 8, this implies

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that 300 x 10 x 8 = 24,000 root carrot (rc). Therefore, Deckfarm 1 - (D1) = 24,000rc which was then used to multiply the unit price to give the research the capacity returns quarterly.

II. MATERIALS AND METHOD

A. Materials

Site selection – KNUST Campus, PVC Pipes (5inch), PVC Pipes (1inch), Fence (security of crops), Wheel barrow, Shovel, Pick arks, Cutlass, rake, Sacks, PolyTank, Iron Bars, Wire, Metal plates, Cement, Stones and organic compost, seeds of maize, chilli pepper, lettuce, cabbage and tomato [8].

Figure 1: Compost and compost materials (River weed 10%, Banana straw 10%, Loamy sand 80%)

B. Methodology

The study installed 120 Sackfarm and 1 Deckfarm system on a 250m^2 land after the land has been cleared of weeds and properly laid out and four marketable crops were consider at various seasons for production i.e. Maize, Chilli Pepper, Tomato, Cabbage and Lettuce. Economic benefits of yield from the maize and the vegetable crops within the first quarter of the year covered cost of production and therefore not much profit was made. There was mechanized borehole and nursery installation before the main installation of the project.

Figure 2: Methodology flow Chart

Construction, Nursery and Transplanting: The Sackfarm and Deckfarm were given serial numbers in order to detect and ensure that any problem associating with any of the Sackfarm or Deckfarm was quickly detected and addressed. The number of crops, growth level, maturity level, diseases and pest on each sack was recorded and addressed. Despite the use of organic means to control pest and diseases every vegetable rested under a net so tiny enough to prevent pest attack while allowing sunlight penetration.

Figure 3: the construction phase

Pest and Disease Control – Biological Control: The study made use of neem tree (back, fruits and seeds and leaves) which was grinded and mixed into paste. The crops were sprayed with the outcome mixture and there were no recorded incident of pest and diseases especially aphids [9]. The active ingredient in the neem tree prevented these small plant-sucking insects from attacking and feeding on the crops.

Figure 4: Biological pest and disease control with Neem tree products

Data Collection and Statistical Analysis: Data collection was made on the maize due to the root depth and water requirements.

- Amount of water applied
- Growth Parameters – stem, number of leaves, leaf area Index etc.
- Yield Parameters [10]
- Drip Irrigation Efficiency
- Laboratory testing of heavy metals [11] in crops

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using and

Statistical Analysis of Variance (ANOVA) to test the least significant differences among replicates using MATLAB version 16a for plots, tables and charts. Qualitative and quantitative data collected on number of plants and crop yield was validated for reliability during the study [12].

Figure 5: Transplanted vegetables

III. RESULTS AND DISCUSSION

A. Water requirement

Table 1 shows the water requirement during the crop's growing season as well as the irrigation water used in the treatment plots. There are four crop development stages that are taken into account, i.e. initial, crop development, mid and late stages. The study is focused on supply of water through rainfall and irrigation during all these four stages. There was non-uniform water flow from drip hole. Treatment of 40 cm, 20 cm and 0 cm depth were irrigated within an interval of three days. Treatment with no irrigation showed wilting symptoms that indicated critical water stress during the growing stage as compared to irrigated lands [13]

***Table 1**. Amount of water supplied during the growing season (i.e. irrigation water plus effective rainfall) for all treatments.*

Treatment	**Irrigation water supplied (mm)**	**Effective rainfall during crop growing stages (mm)**				**Total water supplied: Irrigation water + Effective rainfall (mm)**
		I	**II**	**III**	**IV**	
40 cm Depth	162.1– 338.9	119.245	181.61	135.89	0	598.845 - 775.645
20 cm Depth	162.1– 338.9	119.245	181.61	135.89	0	598.845 - 775.645
0 cm Depth	16 162.1– 338.9	119.245	181.61	135.89	0	598.845 - 775.645
No Irrigation	**0**	119.245	181.61	135.89	0	436.745

***Table 2**.Growth Parameters*

Treatment	**WK 1**	**WK 2**	**WK 3**	**WK 4**	**WK 5**	**WK 6**	**WK 7**	**WK 8**
Plant height								
0 cm	5.0350	13.950	34.450	60.750a	93.70 c	165.50	165.50	166.00 c
20 cm	5.2150	12.250	30.250	56.950b	101.55a	170.98	170.98	177.85 a
40 cm	5.3050	12.125	31.250	54.250c	99.00 b	159.10	159.10	171.60 b
No Irrigation.	4.9100	13.250	32.650	46.150d	72.95 d	126.90	126.90	132.76 d
LSD (P<0.05)	**NS**	**NS**	**NS**	**13.24**	**1.60**	**NS**	**NS**	**43.91**
Stem girth								
0 cm	1.1400	2.5950	5.5600	7.1300	7.5450	8.3950	8.3950	8.8050 b
20 cm	1.1400	2.3400	4.8050	6.7050	7.8300	8.7750	8.7750	8.9500 a
40 cm	1.1650	2.2650	4.8200	6.6400	7.8250	8.7100	8.7100	8.6750 a
No Irrigation.	1.1700	2.2450	5.1700	6.0550	6.6950	6.9950	6.9950	8.7650 c
LSD (P<0.050)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1.6**
Number of leaves								

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0 cm	2.8500	7.0500	10.300	12.650a	13.650	13.800	13.800	12.650 b
20 cm	2.8000	6.5500	9.650	12.600a	13.900	14.000	14.000	13.150 a
40 cm	2.8500	6.6000	9.900	12.150b	13.800	13.350	13.350	12.850 b
No Irrigation.	2.7000	6.8500	10.050	10.900c	12.450	13.500	13.500	10.400 c
LSD (P<0.05)	**NS**	**NS**	**NS**	**1.54**	**NS**	**NS**	**NS**	**1.6**
Leaf diameter								
0 cm	1.4700	3.5400	7.4500	8.765	9.245	9.105	9.020 b	9.370 a
20 cm	1.15500	3.3250	7.2150	8.665	9.505	9.410	9.120 b	9.030 a
40 cm	1.15650	3.4500	7.2100	8.920	9.765	9.690	9.515 a	8.880 b
No Irrigation.	1.13500	3.1400	7.6100	8.460	9.180	8.360	7.610 c	7.055 c
LSD (P<0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1.5**	**1.5**
Leaf length								
0 cm	6.3450	28.7250	50.750	66.205	70.500	70.415	70.360	73.585 a
20 cm	6.3400	25.2500	48.525	65.300	75.100	72.925	71.600	71.165 ab
40 cm	5.9700	26.2000	50.185	66.050	72.025	74.280	73.850	69.945 b
No Irrigation.	6.3200	25.4250	48.800	59.100	67.525	66.825	62.425	58.670 c
LSD (P<0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**12.29**

Treatment means having the same letters along the column are not significantly different from each other at $P < 0.05$

A. Growth parameters

The plant height showed a significant difference at Week 4, 5 and Week 8. There was no significant difference on the stem girth from week 1 to Week 7 against ‘No Irrigation’ and the irrigated treatments (40cm, 20cm and 0cm water application depth), but significant difference showed up in week 8 against ‘No Irrigation’ and the irrigated treatments. Weeks 4 and 8 appeared to have a significant difference in terms of the leaf diameter against ‘No Irrigation’ and the irrigated treatments. Leaf length showed a significant difference at the 12th Week against ‘No Irrigation’ and the irrigated treatments, as indicated in Table 2.

B. Yield parameters

The dry matter yield and above and below ground biomass of the maize plant is presented in Tables 3 and 4 respectively. ANOVA test showed that there is a significant difference between treatments in terms of dry matter yield and above and below ground biomass. It was evident that there was a significant difference between 40 cm, 20 cm and 0 cm and ‘No Irrigation’ treatment. It was also evident that there were significant differences between irrigated treatments and ‘No Irrigation’ treatments.

The grain yield varied from 6085 kg/ha – 2297kg/ha at 13.5% moisture content. The above ground biomass, below ground biomass and root length also varied from 12670 kg/ha – 5945 kg/ha, 1992.9 kg/ha - 1385.6 kg/ha and 29.850 cm - 28.125 cm respectively. The maximum yield was obtained from the treatment which the water application depth was 20cm.

Figure 6: Organic Maize under drip irrigation

Table 3.*Grain dry matter yield*

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Treatment	Mass of fresh cob kg/ha	Mass of Dry cob kg/ha	Mass of Wet grain + corn-cob kg/ha	Mass of Dry grain + corn-cob kg/ha	Mass of Corn-cob kg/ha	Mass of Wet grain kg/ha	Mass of Dry grain at 13.5% moisture kg/ha
0 cm	12534 b	9640 b	8260 b	7336 b	1484.8 a	5851.2 b	5320.0 b
20 cm	14051 a	10795 a	9192 a	8204 a	1384.9 b	6818.7 a	6085.1 a
40 cm	12756 b	9557 b	8189 b	7265 b	1372.3 b	5893.2 b	5050.6 b
No Irrigation	6821 c	4604 c	3778 c	3255 c	647.6 c	2610.8 c	2297.0 c
LSD(0.05)	**4796.55**	**3368.94**	**923.19**	**2777.99**	**702.99**	**2352.66**	**1984.65**

*Treatment means having the same letters along the column are not significantly different from each other at P < 0.*05

***Table 4.** Means of above and below ground biomass determination*

Treatment	Above ground biomass (kg/ha)	Below ground biomass(kg/ha)	Root length(cm)
0 cm	12670 a	1992.9	29.850 a
20 cm	12057 c	2084	29.850 a
40 cm	12345 b	1862.2	29.025 b
No Irrigation	5945 d	1385.6	28.125 c
LSD (0.05)	**6143.98**	**NS**	**1.5**

Treatment means having the same letters along the column are not significantly different from each other at P < 0.05

The highest above ground biomass was obtained from treatment 0 cm and lowest was 'No Irrigation' treatment, 0 cm and 20 cm treatment recorded the highest root length and lowest was recorded on 'No Irrigation' treatment. There was no significant difference between treatments for the below ground biomass (Table 4).

For further comparison, it is important to classify the results into four as indicated on Table 5 to show the relationship between the effects of water application depth on maize growth and yield performance.

From Table 5 below it can be inferred that, the 20 cm depth of water application treatment produced significantly the highest dry matter yield, above ground biomass and below ground biomass, whilst the 'No Irrigation' treatment produced the least in terms of dry matter yield, above ground biomass and below ground biomass [14].

***Table 5.**Grain yield (13.5% moisture content), above and below ground biomass for maize under different treatments*

Treatments	Mass of dry grain at 13.5% kg/ha	Above ground biomass (kg/ha)	Below ground biomass(kg/ha)	Root length(cm)
0 cm	5320.0 b	12670 a	1992.9	29.850 a
20 cm	6085.1 a	12057 c	2084	29.850 a
40 cm	5050.6 b	12345 b	1862.2	29.025 b
No Irrigation	2297.0 c	5945 d	1385.6	28.125 c
LSD (0.05)	**1984.65**	**6143.98**	**NS**	**1.5**

Treatment means having the same letters along the column are not significantly different from each other at P < 0.05

Table 6. Laboratory results for all the heavy metals. The * denotes those results the concentrations of which were below limits of detection of allowable by World Health Organization

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No of Weeks	Cd	Ni	Hg	As	Pb	V	Cr
	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g
1	*	0.0007	*	0.0026	0.0877	0.0026	*
2	*	0.0005	0.0002	*	0.1341	*	*
3	*	0.0001	*	*	0.0945	0.0026	*
4	*	0.0000	*	*	0.1794	*	*
5	0.0013	0.0006	*	*	0.0947	0.0042	*
6	*	0.0oo7	*	*	0.1962	*	*
7	*	0.0338	*	*	0.1383	0.0184	*

A. Laboratory test: Lettuce

Table 6 clearly shows the laboratory test for the presence of heavy metals on the vegetables produced. Major heavy metal of concern were Mercury (Hg), Arsenic (As), and Nickle (Ni) but the study found out that, the prepared compost had little or no heavy metals and even when there were traces, they are not anywhere near the allowable consumption as stated by the World Health Organization (WHO). The WHO puts Hg consumption allowable at 0.15 μg/g as stated in [14], but the study recorded 0.0002 μg/g of Hg in the second week of the lettuce growth which has little effect on health.

Figure 7, which shows the (LAI) depicts a good leaf formation throughout the various vegetables produced per the number of weeks that measurements were taken. This indicates better nutrient availability to the plants and good irrigation and water availability throughout the study.

Table 7. Space Management using Sack and Deckfarm Approach – Lettuce.

Item	Sack (Experimental) Method
Land Size used	250 m^2
No. Sacks	120
No. of holes created	30
No. of lettuce plants	4000

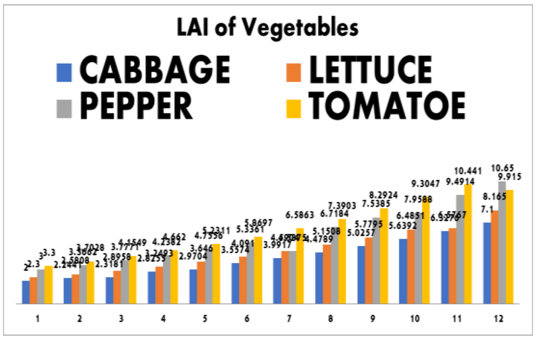

Figure 7: Leaf area index of vegetables

Figure 8: Sample organic vegetables produced from the study.

Plain land planting distance is for lettuce 0.4064 m^2 per 4 crops

Therefore, 4000 lettuce plants on a plain field = *4000 L ×0.4064 m24 L*

= 406.4 m^2

∴ % increase in planting space needed for traditional plain field planting is

= *406.4-250m2250 m2 ×100%*

= *156.4250 ×100 %*

= *0.6256×100 %*

= 62.56 % of Land space saved

IV. CONCLUSION

The advantages of practising drip irrigation lie in saving water while increasing growth parameter and grain dry matter yield in maize and other crops. The study indicated that there was a significant difference between the growth parameters under drip irrigation (40cm, 20cm and 0cm water application depth) and the No irrigation treatment.

The study also indicated that grain dry matter yield was significantly different among and between treatments. In all treatment 20 cm produced the highest grain dry matter. It is therefore appropriate to place the drip hole at 20 cm below the ground surface.

There was high yield within all the plants and plants were more fresher and less poisoned with chemicals as indicated in table 6. The work saved space (**62.56 %),** labour and resources and created high job opportunities for the community close to the study site.

The farm held a capacity of 120 sacks and 1 Deckfarm (D1) systems for the initial investment and the study has indicated sustainability methods of saving the environment and providing food for developing and developed countries as a whole because a single design project has the capacity of feeding the entire nation of Ghana and push many out of the hunger and poverty line.

Again, the laboratory test on the vegetables showed no or little traces of heavy metal elements and therefore suggest that, organic agriculture is a sure of controlling diseases related to diet which mostly leads to cancer.

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