Assessment of the Potential Use of Hydroponic Effluents for Fodder Production

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Abstract: The performance of Guatemala grass (*Tripsacum laxum*) under fertigation using hydroponic effluents at different dilution rates (effluent:water: 4:0, 3:1, 1:1, 1:3, 0:4) was compared to fertilisation using farmers' fertiliser rate of 475 kg 17:8:25/ha applied at planting + 235 kg Sulphate of Ammonia/ha applied as top dressing one month after and 150 kg 17:8:25/ha applied after each harvest. Yield response obtained in plots fertilised using undiluted hydroponic effluents was 16.7% lower than that recorded in plots fertilised using farmers' fertiliser rate. The study showed that there is potential for using hydroponic effluents (undiluted or diluted in the ratio of 3 HE: 1 water) in fodder production as it can provide sustainable yield in the range of 39.5-41.7 t/ha per harvest. Moreover, dilution rate of hydroponic effluents has a direct impact on crop development and fresh biomass yield. Fodder crop yield responded negatively to the increase dilution of hydroponic effluents from 4HE: 0 water to 3HE: 1 water, 1HE: 1 water and 1HE: 3 water. Consequently, the use of hydroponic effluents can eventually help to save on mineral fertiliser use and reduce cost of production while at the same time address environmental hazards related to hydroponic effluents disposal.

Key words: Performance, hydroponic effluents, environmental hazards.

1. Introduction

Reducing agricultural water use while maintaining or improving economic productivity of the agricultural sector is a major challenge [1]. Nevertheless, the use of wastewater in agriculture is increasing due to water scarcity and population growth [2]. Wastewater reuse in agriculture represents a potentially important alternative for fresh water thereby saving it for drinking and industry water supplies [3]. However, the use of wastewater in agriculture needs to be done with precautions to avoid harming the agricultural soils and to prevent any consumer health risk. Therefore, methods and technologies that can contribute to improve water use efficiency and productivity merit closer consideration like the use of hydroponic effluents in crop production. In this study, the use of wastewater from hydroponic cultures was largely limited to irrigation of forages only [4].

Wastewater is indeed an indispensable non-conventional water resource which is increasingly used as an essential alternative for limited freshwater resources [5]. One of the benefits is plant's uptake of water nutrients and therefore a reduction in pollution load which wastewater contributes to surface water supply [6] as well as reduction in use of synthetic inorganic fertilizers [5].

Historically, Mauritius has been depending heavily on sugar production and exports, but currently the sugar sector is under pressure. For many years, the EU sugar regime has favoured Mauritius sugar producers with huge prices. However, now the Mauritius sugar producers have to compete on the global market. As a result, there is a shift away from sugar. At the same time, government policy is attempting to bring the country nearer to self-sufficiency in the food production sector. Land released by reduction in sugar production is being used for crops and livestockrearing. The livestock sector is one which offers great potential for new Small and Medium Enterprises (SMEs) and due to inflation, Mauritius

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have already back peddled towards traditional culture values. The livestock sector is currently rising into prominence and a huge response is being received by the Food and Agricultural Research and Extension Institute towards the enhancement of livestock rearing into SME development [7].

With urbanisation and changing climate, one of the constraints to improve livestock production in Mauritius is the scarcity of quality of feed resources such as grasses/forage and the low productivity of pasture land. Given the limited land resources for pasture development, the government policy is to provide incentive for farmers to invest in intensive fodder production to meet the feed requirement of the growing livestock industry [7].

Under the Food Security Fund project [7], Government policy has been to increase self sufficiency in the production of fresh milk and meat. However, the prerequisite for boosting the local dairy and meat production sector is to encourage production of feed (fodder). Sustainable quality fodder production requires inputs in terms of water and nutrients. Hence the purpose of this project was to investigate the potential of using the hydroponic effluents as a source of nutrients for forage production.

2. Methodology

The performance of Guatemala grass was evaluated under fertigation using hydroponic effluents at different dilution rates (hydroponic effluents: water-4:0, 3:1, 1:1, 1:3, 0:4). A treatment using farmers' fertiliser practice of 475 kg 17:8:25/ha applied as basal treatment and 235 kg Sulphate of Ammonia/ha applied as top dressing followed by 150 kg of 17:8:25 applied after each harvest [8] were included in the experiment for comparison purposes.

The 6 treatments were as follows:

T1: Fertigation using undiluted Hydroponic effluents (4 HE: 0 Water)

T2: Fertigation using diluted hydroponic effluents

(3 HE: 1 Water)

T3: Fertigation using diluted hydroponic effluents 1 HE: 1 Water

T4: Fertigation using diluted hydroponic effluents 1 HE: 3 Water

T5: Farmers fertiliser practice

T6: Water only (0 HE: 4Water)

Guatemala crop was established using cuttings of 3 nodes planted 40 cm within the row spaced 75 cm apart. The plot treated with farmers fertiliser practice (T5) was irrigated using drip system and received same volume of water as that of the plots under fertigation (T1, T2, T3, T4 and T6).

Application of hydroponic effluents as per respective fertigation treatments was initiated 2 months after planting. The amount of water/hydroponic effluents applied per day was 1.68 L/m² at initial stage, 5.25 L/m² at mid interval and 3.15 L/m² during the end of the crop cycle respectively. Random samples of undiluted hydroponic effluents used for the experiment were collected and analysed for soluble nutrient content. The Guatemala plant growth was monitored using stem height, canopy development and leaves colour and the fodder yield was recorded for the different treatment plot. The completely randomized design was used with four replicates. Data were statistically analyzed using analysis of variance (ANOVA) according to the statistical package.

3. Results

3.1 Nutrient Content of Hydroponic Effluents

Random Sample of hydroponic effluents analysed prior to application in field plots is detailed in Table 1. The findings showed that hydroponic effluents contain sufficient amount of nitrate, phosphate, potassium, sodium, calcium and Magnesium and also trace elements such as Zn, Fe, Cu, Mn and can be reused as a source of plant nutrients for crop production. Given its high soluble nitrate and phosphate content, the

Table 1 Average nutrient content of hydroponic effluents.

Soluble nutrients	Composition (ppm)
Nitrate	320.00
Phosphate	44.02
Sulphate	38.42
Potassium	122.00
Sodium	68.60
Calcium	88.36
Magnesium	51.86
Zinc	0.33
Iron	0.68
Copper	0.22
Manganese	0.12

disposal in the environment can result in environmental pollution.

3.2 Stem Height

Guatemala stem heights recorded 3 months after each harvest showed significant difference among the different treatments. The mean fodder stem height was

significantly higher in plots irrigated with hydroponic effluents and fertilised using farmers fertiliser practice compared to plots irrigated using only water. Stem height was observed to decrease from 99 cm to 54 cm (Table 2) with increasing dilution factor of the hydroponic effluents from 4:0 to 1:3 and 0:4. Mean plant stem height recorded in plots treated with farmers fertiliser practice was 103 cm as compared to 99 cm in plots under fertigation with undiluted hydroponic effluents.

3.3 Canopy Development and Leaves Colour

Figs. 1 and 2 depict the difference in colour of Guatemala fodder under different treatments. It was observed that guatemala crop under fertigation with undiluted hydroponic effluents developed larger plant canopy with dark green colour leaves as compared to small plant canopy with pale green leaves colour as shown in Figs. 1 and 2.

Table 2 Average stem height recorded per treatments.

Treatment	Average stem height (cm)
T1: Fertigation using undiluted hydroponic effluents (4 HE: 0 Water)	99
T2: Fertigation using diluted hydroponic effluents (3 HE: 1 Water)	83
T3: Fertigation using diluted hydroponic effluents (1 HE: 1 Water)	68
T4: Fertigation using diluted hydroponic effluents (1 HE: 3 Water)	54
T5: Farmers' fertiliser practice + water	103
T6: Water only (0 HE: 4 Water)-Control	39

Fig. 1 Guatemala under fertigation with undiluted hydroponic effluents.

Fig. 2 Guatemala under farmers' fertiliser practice + water.

It was also noted that, based on the plant canopy development, fodder in plots under fertigation using undiluted hydroponic effluents was observed to reach harvest maturity stage 3 weeks earlier than which in plots treated with water only.

3.4 Fresh Biomass Yield

During the phase of the experiment, 6 harvests were conducted and it was observed that the plots treated with farmers fertiliser practice rate gave highest cumulated fresh biomass yield of 300.6 t/ha following by 250.2 t/ha recorded in plots under fertigation using undiluted hydroponic effluents (4 HE: 0 Water) while the plot supplied with only water gave the lowest yield of 130.5 t/ha.

Mean cumulated fresh biomass yield recorded through 6 harvests over the 3 years period (April 2011 to April 2014) in plot fertigated using undiluted hydroponic effluents (4 HE: 0 water) was 250.2 t/ha, followed by 237.0 t/ha recorded in plots fertigated using hydroponic effluents diluted in ratio of 3HE: 1 water, 222.2 t/ha recorded in plots fertigated using hydroponic effluents diluted in ratio of 1HE: 1water and 183.0 t/ha in plots fertigated using hydroponic effluents diluted in ratio of 1 HE: 3 water. It was also

noted that, the cumulated yield in plots fertigated using undiluted hydroponic effluents was 16.7% lower than that recorded in plots conventionally fertilised using farmers fertiliser practice with same water regime.

Cumulated fodder yield increased from 130.5 t/ha in the control plot irrigated using only water to 183 t/ha in plots under fertigation with 1 HE: 3 water to 250.2 t/ha in plots with undiluted hydroponic effluents (4 HE: 0 water).

This clearly demonstrated that the yield responded positively to an increase in volume of hydroponic effluents in the mixture used for fertigation due to the increase in availability of soluble plant nutrients.

The mean fodder yield recorded per harvest ranged from 21.8 t/ha in control plot to 50.1 t/ha recorded in the plot fertiliser using farmers' fertiliser practice (Table 3). It was generally observed that the yield recorded per harvest gradually decreased over time in plots treated with hydroponic effluents diluted in the ratio of 1 HE: 1 Water and 1 HE: 3 water. The yield per harvest in plots under fertigation with 1 HE :3 water was observed to decrease from 40.4 t/ha in the first harvest to 19.5 t/ha in the 6th harvest. This may be due to mining of the indigenous soil nutrients over

Table 3 Average fresh biomass yield of Guatemala grass planted in April 2011-April 2014.

Treatments	1st harvest	2nd harvest	3rd harvest	4th harvest	5th harvest	6th harvest	Mean /harvest $\pm$ SD	Cumulated yield(t/ha)
	Jan. -12	May -12	Dec. -12	Apr. -13	Nov. -13	Apr.-14		
T1: Fertigation with undiluted Hydroponic effluents (4 HE: 0 Water)	34.2	28.9	42.7	49.3	46.6	48.5	41.7 $\pm$ 8.4	250.2
T2: Fertigation using diluted Hydroponic effluents (3 HE: 1 Water)	41.9	40.2	33.4	44.2	47.8	29.5	39.5 $\pm$ 6.9	237.0
T3: Fertigation using diluted Hydroponic effluents (1 HE: 1 Water)	76.3	71.4	14.4	21.9	22.7	15.5	37.0 $\pm$ 28.8	222.2
T4: Fertigation using diluted Hydroponic effluents (1 HE: 3 Water)	40.4	34.9	27.2	31.5	29.5	19.5	30.5 $\pm$ 7.1	183.0
T5: Farmers' fertiliser practice + water	65.5	49.8	43.8	49.6	36	55.9	50.1 $\pm$ 10.1	300.6
T6: Water only (0 HE: 4 Water) - Control T6	11.4	45.2	16.2	18.6	19.9	19.2	21.8 $\pm$ 11.9	130.5

Table 4 Percentage increase in fresh biomass yield recorded per harvest for each treatment as compared to control plot.

Treatment	% increase in yield as compared to control
T1: Fertigation using undiluted hydroponic effluents (4 HE: 0 Water)	91.7
T2: Fertigation using diluted hydroponic effluents (3 HE: 1 Water)	81.6
T3: Fertigation using diluted hydroponic effluents (1 HE: 1 Water)	70.3
T4: Fertigation using diluted hydroponic effluents (1 HE: 3 Water)	40.2
T5: Farmers' fertiliser practice + water	130.3
T6: Water only (0 HE: 4Water) - Control	<i>Not applicable</i>

time due to low inputs in nutrient. Moreover, variation in fodder yield recorded per harvest within one treatment may also be attributed to slow plant growth during the cool winter months and experimental errors.

The use of mineral fertiliser at farmers' fertiliser practice of 475 kg 17:8:25/ha applied as basal treatment and 235 kg SoA/ha applied as top dressing and 150 kg 17:8:25/ha after each harvest yield 130.3% higher yield than the unfertilised plot (treatment 6). Similarly the use of undiluted hydroponic effluents yielded 91.7% higher biomass yield/harvest as compared to the control plot (Table 4).

4. Conclusion

With the rise in water demand the use of wastewater for forage production from hydroponic cultures is well endorsed. The latter could be used in areas where water is a main limiting factor for agricultural production. This study proved that there is potential of using the hydroponic effluents (undiluted or diluted in the ratio of 3 HE: 1 water) in fodder production as it can provide sustainable yield in the range of 39.5-41.7 t/ha per harvest over time. It also indicates that the hydroponic effluent is a good source of nutrients needed for plant growth thereby promoting high yields. The use of hydroponic effluents is also considered as an environmentally sound waste water disposal practice compared to direct disposal into surface or ground water bodies. Hydroponic effluents could in the long term play a

significant role in improving water use efficiency.

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