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Productivity and nutritional composition of maize fodder grown by hydroponic and conventional methods

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Abstract
Productivity, biomass yield and nutritional composition of maize fodder grown for the same period of duration and under same area of production both by hydroponic and conventional methods were compared in this study. Hydroponic maize fodder was produced using 3 ft wide, 4 ft long low cost hydroponic green fodder machine fabricated at TANUVAS. Maize was processed or two days and grown inside the hydroponic machine for 8 days. After 8 days of growth period in the machine the fodder was harvested on the 9th day. Four plots of 4 ft X 3 ft size were divided into two groups namely, group 1 (normal sowing rate - 40 kg / ha i.e. 5 g /plot.) and group 2 (hydroponic production method rate - 6 kg/ plot) each having two plots. All the plots were harvested at day 10 after sowing. Parameters such as total fodder yield, seed to fodder production ratio, root biomass, shoot biomass and proximate composition were studied. Hydroponic maize fodder had significantly higher (P< 0.01) total fodder yield, seed to fodder production ratio and root biomass compared to land grown maize fodder. Hydroponic maize fodder (P< 0.01) had significantly lower moisture, EE and TA; and significantly higher DM, CF, NFE and TDN compared to land grown maize fodders. CP content of hydroponic maize fodder was similar to that of land grown maize fodder (6 kg/plot) but significantly (P< 0.01) lower to land grown maize fodder (5 g/plot). To conclude, with the same growth period and area of production; hydroponic method of fodder production yields higher fodder with better nutritional quality than conventional method.

Keywords: Hydroponic maize fodder, conventional maize fodder, productivity, nutritional composition

Introduction
Growing of plants without soil but in water or nutrient solution in a greenhouse (hi-tech or low cost devices) for a short duration (approx. 7-8 days) is hydroponics fodder production [1]. Hydroponic fodder is a palatable and germinated grain embedded in the root system, consumed along with the shoots of the plants without any nutrition wasting [2].

In agriculture hydroponics is an advanced technology. Hydroponic production is used to guarantee a constant production of high quantity of green forage throughout the year for livestock feed with suitable prices. Hydroponics avoids problems shown in conventional methods of fodder production. This is realized through use of mall piece of land with vertical growing process that permits production of a large volume of hydroponic fodder on a fraction of area needed by conventional fodder production and thus increases stocking capacity of livestock [3]. The green fodder from hydroponics is highly palatable, easily digestive and of better quality as compared to traditional fodder production [1].

In India, easy availability of seed, lower seed cost, good biomass production and quick growing habit; maize is the choice of grain for hydroponics fodder production. The hydroponics green fodder looks like a mat of 20-25 cm length consisting of roots, seeds and stems. To produce one kg of fresh hydroponics maize fodder (7-d), about 1.50 - 3.0 litres of water is required. Yields of 5-6 folds on fresh basis and DM content of 11-14% are common for hydroponics maize fodder [1].

With this background this study was formulated to compare the productivity, biomass yield and nutritional composition of maize fodder grown for the same period of duration and under same area of production both by hydroponic and conventional methods.

Materials and Methods
Production of hydroponic maize fodder (HMF)
Low cost hydroponic green fodder machine: Hydroponic maize fodder was produced using the TANUVAS – UIIC - Low cost hydroponic green fodder machine fabricated at University Innovation and Instrumentation Centre (UIIC), TANUVAS.

It is 3 ft wide, 4 ft long and 6 ft high machine consisting of two sections made up of iron frame. Each section contains 8 rows consequent to the 8 days of growth period. Each row consists of 3 plastic hydroponic trays. The hydroponic trays are held in place by 'L' shaped beading on either side made up of 22 gauge GI sheet. Each row of the hydroponic machine is fitted with drip pipe on either side. The drip pipe is fitted with misting nozzle in such a way that each tray will have one misting nozzle on either side for watering the plants as well as to maintain the temperature at a range of 22 – 27 ^{0}C and relative humidity up to 70%. The machine is covered with 90% green shade net on all sides which permits the entry of sunlight needed for plant growth.

Method of hydroponic fodder production: Recently harvested good quality yellow maize seeds with less than 12% moisture were selected. The seeds were winnowed to remove chaffs and dirt's and sun dried the day before soaking. Required quantity of seeds i.e. 6 kg/ machine were then weighed and washed in tap water to remove remaining chaffs and dirt's. The seeds were then soaked in tap water for 20 hours (Figure 1). Water was then drained and the seeds were packed in gunny bags for germination (Figure 2 - 3). Water was sprinkled periodically over the gunny bag to maintain moisture. After 24 hours, germinated seeds were taken out from the gunny bags and loaded onto 6 different hydroponic fodder trays at the rate of 1 kg per tray (dry weight). After loading the trays with germinated seeds, the trays were kept on the lowest row of the hydroponic fodder machine (Figure 4). Each tray in the sprout section is provided with one sprinkler on either side for irrigation. Water was sprinkled every hour for about 4 minutes. The trays were shifted to immediate upper row daily. After 8 days of growth period in the machine the fodders were taken out on the 9th day for analysis (Figure 5).

Fig 1: Soaking of yellow maize seeds

Fig 2: Packing in gunny bags

Fig 3: Germinated seeds after 24 hours

Fig 4: Trays with germinated seeds placed in the TANUVAS – UIIC – Low cost hydroponic green fodder machine

Fig 4: Harvested hydroponic maize fodder

Production of land grown maize fodder (LMF)

Ploughing: The field to be divided into plots was ploughed mechanically using tractor thrice at an interval of one week before plot preparation.

Application of farm yard manure (FYM): Farm yard manure was applied at the rate of 10 ton/ acre before ploughing.

Preparation of plots: Four plots of 4 ft X 3 ft size were created corresponding to the size of hydroponic machine utilized for the study ((Figure 6). Ridges were formed at the boundary of each plot. The plots were divided into two groups namely, group 1 (normal sowing rate) and group 2 (hydroponic production method rate) each having two plots.

Sowing: Plots under group 1 were sowed with yellow maize seeds as per normal sowing rate of 40 kg / ha i.e. 5 g /plot (Figure 7). Similarly the plots under group 2 were sowed at the same rate as hydroponic machine i.e. 6 kg/ plot (Figure 8).

Water management: Life irrigation was given immediately after sowing. Thereafter, irrigation was done once in 3 days up to 10 days and then once in 10 days up to harvest.

Weed management: Manual weeding was done as and when necessary.

Harvesting: All the plots were harvested at day 10 after sowing (Figure 9,10). For hydroponic fodder production it takes 2 days or seed processing outside the machine and 8 days of growth inside the machine hence a total of 10 days was fixed as growth period for growing in land.

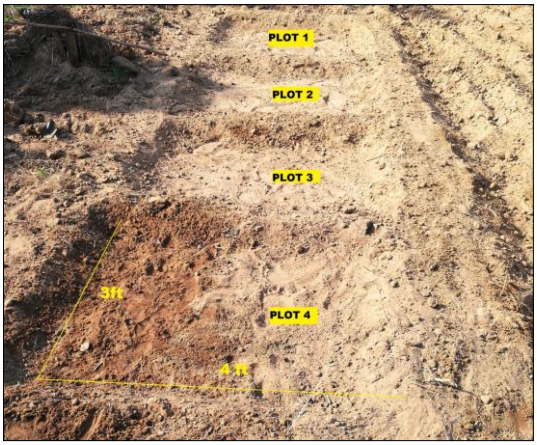

Fig 6: Plot Preparation

Fig 7: Sowing rate of 40 kg / ha i.e. 5 g / plot

Fig 8: Sowing rate of 6 kg /plot

Fig 9: Day10 (Sowing rate 5 g / plot)

Fig 10: Day 10 (Sowing rate of 6 kg /plot)

Results and Discussion

Productivity and biomass yield of hydroponic and land grown maize fodder:

The observations made in the present study revealed that the total fodder yield (31.57±0.13 kg), seed to fodder production ratio (1:5.26 kg) and root biomass (66.67±0.66%) were significantly (P<0.01) higher in hydroponic maize fodder compared to land grown maize fodders, while the shoot biomass was significantly higher (P< 0.01) in land grown maize fodders 6 kg/plot and 5 g/plot (90.33±0.44%, 89.25±0.38%) compared to hydroponic maize fodder (33.33±0.66%) as seen in Table 1.

The seed to fodder production ratio for hydroponic maize fodder observed in the present study was in accordance with Naik *et al.* [4] who reported a 5.5 folds increase and slightly higher that the ratio reported by Gunasekaran *et al.* [5] who observed a biomass yield of 4.55±0.08 kg / kg of seed in hydroponic fodder maize.

The root and shoot biomass yield of hydroponic maize fodder observed in the present study were in accordance with Jemimah *et al.* [6] and Naik *et al.* [7] who reported a root biomass of 70 ±0.52%, 68.58% and shoot biomass of 30±0.49, 31.42%, respectively in hydroponic maize fodder. The higher root biomass in hydroponic maize fodder is due to the presence of root mat along with seeds and the higher shoot biomass in land grown maize fodder is due to loss of seed during germination and root during fodder harvesting.

Table 1: Productivity and biomass yield of hydroponic and land grown maize fodder Machine / Plot size: 4 ft X 3 ft

Parameters	Hydroponic maize fodder	Land grown maize fodder		'F' value
		6 kg / plot	5 g / plot	
Total fodder yield (kg)	31.57^{a}±0.13	16.66^{b}±0.76	0.0574^{c}±0.07	6139.78**
Seed: fodder production ratio (kg)	1: 5.26^{a}	1:2.77^{b}	1:0.001148^{c}	85.09**
Root biomass (%)	66.67^{a}±0.66	9.67^{b}±0.44	10.75^{bc}±0.38	4063.12**
Shoot biomass (%)	33.33^{a}±0.66	90.33^{b}±0.44	89.25^{b}±0.38	4063.14**

** Significant at one per cent level (P< 0.01)
Means bearing different superscript in the same column differ significantly

Nutritional composition of hydroponic and land grown maize fodder

Nutritional composition of hydroponic and land grown maize fodder were given in Table 2. In the present study, hydroponic maize fodder has significantly lower moisture, EE and TA and significantly higher DM, CF, NFE and TDN compared to land grown maize fodders. CP content of hydroponic maize fodder was similar to that of land grown maize fodder (6 kg/plot) but significantly (P< 0.01) lower to land grown maize fodder (5 g/plot).

The results were in accordance with Girma and Gebremariam [3] who stated that conventional fodders are less nutritious than hydroponic fodders and the nutrient deviation occurs during sprouting increases the crude protein, ether extract, nitrogen free extract but decreases the crude fiber, total ash and insoluble ash. The nutritional composition of hydroponic maize fodder observed in the present study were slightly lower than that reported by Naik *et al.* [8] who observed the DM content of the hydroponically sprouted maize grains as 18.30% and the CP, EE, CF, NFE, TA and AIA content (on % DM basis) as 13.30, 3.27, 6.37, 75.32, 1.75 and 0.57, respectively. The low NFE and high TA in land grown maize fodder observed in the present study were in accordance with Naik *et al.* [8] and Jemimah *et al.* [9] who reported higher TA and lower NFE in conventional maize fodder harvested at about 60 days.

Table 2: Nutritional composition of hydroponic and land grown maize fodder

Parameters	Hydroponic maize fodder (6 kg/ machine/ day)	Land grown maize fodder (6 kg/plot)	Land grown maize fodder (5 g/plot)	'F' value
Moisture (%)	83.42^{a}	85.51^{b}	86.32^{b}	7.3*
DM (%)	16.58^{a}	14.49^{b}	13.68^{b}	6.7*
CP (%)	12.44^{a}	12.01^{a}	20.09^{b}	61.99**
EE (%)	2.65^{a}	10.09^{b}	13.85^{c}	97.46**
CF (%)	9.49^{a}	4.39^{b}	5.04^{b}	23.12*
TA (%)	2.77^{a}	27.03^{b}	18.47^{c}	454.16**
NFE (%)	72.65^{a}	46.48^{b}	42.55^{c}	803.16**
TDN (%)	82.22^{a}	65.13^{b}	73.78^{c}	219.06**

* Significant at five per cent level (P< 0.05)
** Significant at one per cent level (P< 0.01)
Means bearing different superscript in the same column differ significantly

Higher DM, CF, NFE and TDN in hydroponic maize fodder may be due to lower nutrient losses during growth process and higher proportion of root biomass compared to land grown maize fodders. The higher EE content of the land grown maize fodder may be due to the increase in the structural lipids and production of chlorophyll associated with the plant growth [10] and the higher TA may be due to uptake of minerals from the soil by the extending roots during growth and presence of considerable portion of soil in the harvested fodder sample. The increase in dry crude protein content is due to loss in dry matter content particularly carbohydrate. Moreover, nutrient absorption also facilitates the metabolism of nitrogenous compounds which lead to increase the crude protein content [3]. Thus, hydroponic maize fodder is superior to land grown maize fodder of similar growth period and area of production in terms of fodder yield (both dry and fresh matter basis) and nutrient composition.

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