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Research Article

Effect of Urea Fertilization on Agronomic Characteristics and Biomass Yield of Hydroponic Maize Fodder

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Abstract

The objective of this experiment was to investigate the effect of urea treatment on the agronomic characteristics, biomass yield, and its economic feasibility of hydroponic maize fodder grown in a low-cost hydroponic production unit at Arba Minch University's College of Agricultural Science. The hydroponic unit was constructed from locally available materials and 500 grams of maize seeds were planted at the plastic trays at 7.6kg/m^2 seeding rate. For the experiment the known maize seed (BH-540) variety was used. The five level of urea treatments composed of T1 (control), T2 (0.5 % urea), T3 (1.0% urea), T4 (1.5% urea) and T5 (2.0% urea) groups were applied in completely random design (CRD). Urea solution at different levels in the corresponding treatment groups was sprinkled daily two times (at 1 o'clock morning and evening local time) for a total period of 8 days and attributes of agronomic characteristics and biomass yield were recorded at the 9th day of growth. The collected data were analysed using the general linear model of SAS version 9.0 and presented with tables. Among the different treatments T2 group had a higher significant effect ($p<0.05$) and proven to be greater for leaf number (3.56±0.02), leaf area index (9.92±0.33 cm^2), plant height (22.06±0.52 cm), shoot to root ratio (1.07:1.65), biomass yield (2710±94.34 grams/tray), seed to feed ratio (1: 5.42 kg) and dry biomass yield (0.46±0.02 kg/tray) of hydroponic maize. The lowest values were noticed in the T5 group; leaf number (2.64±0.18), leaf area index (3.30±0.18 cm^2), plant height (10.74±0.85 cm), shoot to root ratio (0.40:1.13), biomass yield (1530±167.33 grams/tray), seed to feed ratio (1:3.06) and dry yield (0.31±0.03 kg/tray) of hydroponic maize. Urea application at 0.5% concentrations is optimum for hydroponic maize production as it is believed to favour the cell division, maintains the higher auxin and cytokinins levels which stimulate the cell elongation along the main axis leading to better growth and biomass yield of hydroponic maize fodder.

Key words: Biomass Yield, Hydroponics, Maize Fodder, Nutritional Composition, Urea

1. Introduction

Due to limited resources brought on by climate change and an increase in the global population, traditional agricultural practices have come under pressure. By 2025 and 2050, it is predicted that there will be 8 billion and 9.8 billion people living on the planet, respectively. It is widely understood that in order to feed this expanding global population, agricultural productivity must increase (Yesil & Tatar, 2020). For livestock farmers in the majority of Ethiopia, feed shortages pose a serious challenge. As grazing lands are gradually converted to agriculture to supply the food needs of an increasing human population, livestock are forced to graze on marginal regions, which lead to poor livestock performance when combined with the use of poor-quality crop leftovers as feeds (Gelayenew et al., 2016). Despite being high in fibre but poor in protein and energy, natural pastures from these marginal plains are Ethiopia's main source of animal feed. Particularly when the dry season lasts for a considerable amount of time, these resources have been misused to the point where they are unable to provide the fundamental needs of indigenous species (Getachew, 2021)the success is still low. This review summarizes efforts, challenges, good practices and indicates where the focus of future efforts should be. The efforts made in improve forage production (IFP.

Livestock production in Ethiopia is constrained by a lack of resources and the high cost of imported green feed. Even nevertheless, labour shortages, water constraint, increased fertilizer prices, and lack of suitable fields for cultivating green fodder are the key challenges. In addition, the erratic availability of high-quality green fodder throughout time makes long term dairy production more difficult. Forage production for ruminant animals like sheep, goats, and cattle has been noted as a significant challenge due to the lack of available land. Unlike mono-gastric animals, ruminants do not fully depend on cereal grains. Alternative technologies, such as hydroponics, have grown in importance in light of these and other difficulties (Naik et al 2015a). The performance of the livestock is improved by using this technology as a feed. A larger area of land may be farmed when animal feed is produced using hydroponics.

A technique for sprouting grains or growing plants without soil, using just water or a nutrient-rich solution, is called hydroponics. Hydro means "water" and ponics means "working." Contrarily, hydroponic fodder can be effectively grown without the use of a nutrient-rich solution and can be grown with just pure water (Mohapatra et al., 2019). It is the science of growing plants in nutrient-rich fluids instead of soil, and it can be used to produce green cattle feed to help relieve land pressure (Ye il et al. 2010). Plants require sunlight, water, and nutrients to survive. It involves growing plants or sprouting grains without using soil; instead, it uses water or a nutrient-rich solution. It uses water or a nutrient-rich fluid to sprout grains or grow plants without utilizing any soil. Hydroponic green fodder requires particular growing conditions in particular growing rooms in order to obtain better forage grain germination in a short period of time (Rahman et al., 2020). Fresh forages are produced using seeds including wheat, maize, oat, and barely. The usual fresh forage mat reaches a height of 15 to 30 cm, a weight of 7 to 9 kg, and a dry matter content of 12.85 to 15.75 per cent despite the fact that the development of different species of fodder grains differs at different seeding rates and harvesting date (Adeyemi et al. 2020; Kumalasari 2017). Maize is an essential crop with a wide range of applications. Due to its increased fresh biomass, it is also employed as fodder in addition to grain consumption (Santosh et al. 2021).

Objectives

General Objective

- To evaluate the effect of urea application on agronomic characteristics, biomass yield, and economic feasibility of hydroponic maize fodder

Specific Objectives

- To evaluate the effect of urea application on agronomic characteristics of hydroponic maize fodder
- To evaluate the effect of urea application on the biomass yield of hydroponic maize fodder

2. Materials and Methods

Experiment Site

The experiment was conducted at Arba Minch University College of Agricultural Sciences campus, which is found in Arba Minch town, Southern Nations and Nationalities regional state of Ethiopia, 434.3 kilometres south of Addis Ababa. It is located at 6°02' N latitude, 37°33' E Longitude (Arbaminch town administration, 2017) and at an altitude of 1285 meter above sea level. The average annual rainfall of the area is above 1250 mm and average annual minimum and maximum temperatures are 23°C and 29°C, respectively (Mulugeta et al., 2017) unrefined meteorological data was obtained from National Meteorological Agency (NMA. A small hydroponic unit with dimensions of 3 meters long by 4 meters wide (12 m^2) and a 2.5-meter height was built using items that can be found nearby and plastic sheet to provide a shade. This location was chosen for the nutritional composition study because to its close proximity to the animal nutrition laboratory.

Seed Preparation

15 kilograms of maize (BH-540) seed was purchased from Jinka Agricultural Research Centre (JARC), which were then cleared of debris and other foreign objects. The seed were then soaked for 12 hours after being rinsed three times with tap water. A seed was sterilized after 12 hours of soaking by using hydrogen-peroxide (H_2O_2) solution mixed with tap water for 30 minutes to prevent the growth of mould. Until root mat emerged, soaked seeds were kept in a dark room for 36 hours prior to planting (Bakshi, and Makkar 2017). The hydroponic trays were then covered with sprouting seeds. There were 25 plastic seed trays, each measuring 32 cm long by 23 cm wide (area: 736 cm^2) and 5 cm high.

Seed Planting and Watering

Seeds were placed in planting trays with holes at the bottom to facilitate drainage of extra irrigation water after spending 36 hours in the dark. With a seed rate of 7.6 kg/m^2 for maize, the seeding rates were around 500 grams of maize grain per tray and were applied at the depth of 1-2 cm (Naik, et al. 2017)avg. milk yield 8.57 kg. According to the temperature and the moisture level of the seed, plastic trays were manually watered four times a day (early at 1:00 o'clock in the morning and 1:00 o'clock in the evening water with different levels of urea treatment was applied and additional watering devoid of urea was applied at 5:00 and 9:00 o'clock with a 4-hour interval to reduce the impact of heat and drought) at a fixed volume of 500 ml/tray/day.

Study Design

The experimental design was a completely randomized design (CRD) with four levels of urea application as treatments and one without urea as control. Each treatments level was replicated five times. T1= no urea application taken as a control group, T2= 0.5% (5g/1000 ml of water) urea solution, T3= 1% (10g/1000ml) urea solution, T4= 1.5% (15g/1000ml) urea solution, and T5= 2% (20g/1000ml) urea solution (Latha, 2018). Each treatment had five replications, and paper tags were made for each experimental unit at random.

Watering and Treatment Application

Every morning and evening at 1:00, the urea treatment was added. A 4-hour interval between the spraying of tap water devoid of urea at 5:00 and 9:00 (local time) was applied. The treatment and water were sprayed from plastic bottles that had been punctured at the top manually.

Sampling Techniques

Five replications were used for each dose of treatment. It has five replications of each treatment level, for a total of 25 experimental units (5*5=25). Five degrees of treatments were applied at random with five replications across all experimental units (growing trays with seed). Every experimental unit was measured, and the data collected from units with the same level of treatments were recorded on the same page to calculate the average. Hydroponically grown maize sprouts from experimental units that get the same degree of care was mixed to create a laboratory sample. The fresh samples were noted, oven dried for 72 hours at 60 degrees Celsius, and labelled for transport to Hawassa University animal nutrition laboratory for nutrient analysis.

Methods of Data Collection

The height of the plants was measured by taking into account the maximum distance between the base of the stem and the tip of the longest leaf, in order to assess plant height. Random numbers of leaves from each plant were counted from either side of each tray. And the total weight of the hydroponic maize feed in each tray was weighed and recorded to estimate the fresh yield in kilograms.

At each level of urea application, the agronomic features of hydroponic maize fodder, such as leaf number, leaf area index, plant height, and shoot to root ratio, were observed and recorded. The numbers of leaves were counted, and the leaf area index was calculated by multiplying leaf length with leaf width and then by 0.75 conversion factor and represented in cm^2. While shoot to root ratio is assessed with balance and expressed in %, plant height was measured using a scale and represented in cm.

The biomass yield was calculated by subtracting the tray weight from the weight of the tray containing the fodder on the morning of the 9th day of growing the fodder. To obtain a representative sample for nutrient analysis in the lab, the fodder cake that had received the same level of treatment was disassembled and combined.

Methods of Data Analysis and Presentation

The data collected on agronomic characteristics, yield and nutrient contents were analysed using the General Linear Model procedure of SAS (version 9.0). The model used for data analysis is

$y_{ij}= \mu + \tau i + \varepsilon ij$;

Where: y_{ij} is the ijth observation, μ_i is the mean, τi is the effect of the ith factor/treatment level, and ε_{ij} is a random error.

The data analysis results were presented using tables.

Ethical Consideration

Materials, substances, and information used in this experiment were used solely for the investigation; no further uses were intended. The social and psychological wellness of individuals and the community participated in the research activity was taken into consideration, and the researcher paid the labour costs and per diem for any participants in the investigation as appropriate. For the environment's cleanliness and the safety of those living close to the experiment site, any polluting or dirty materials were carefully disposed of.

3. Results and Discussion

Agronomic Characteristics of Hydroponic Maize Fodder

Leaf Number

The impact of urea fertilization on the number of leaves of hydroponically grown maize fodder is shown in (Table 1). The number of leaves emerged were significantly affected by urea fertilizer ($P< 0.05$). For each level of urea fertilization (0, 0.5, 1, 1.5, and 2%), the average number of leaves counted per plant at the 9th day of growth were 3.14, 3.56, 3.28, 3.22, and 2.64 respectively. At 0.5 per cent urea application level, the largest numbers of leaves (3.56 leaves per plant) were recorded. The average numbers of leaves per plant were 3.28 at 1% level of urea fertilization; but at the 1.5% and 2% levels of urea treatment, the number of leaves declined. The lower number of leaves counted at treatment 5 is due to the higher concentration of urea solution having a negative effect, such as the delay in the development of leaf release in plants on the height of the stem internodes in maize where the leaves are released, so that if the plant has a long stem size, the plant has a higher number of leaves. The number of leaves is proportional to plant height, as the higher the plant, the more leaves it produces.

According to Kustyorini, (2021), the value of this outcome was 3.0 leaves per plant that was given a 5 per cent solution of sheep urine. The number of leaves did not increase when urea was applied in doses up to 10g/litre because, as the dose increased, the plant experienced nutrient saturation and became less able to absorb nutrients, resulting in a reduction in the number of leaves produced. This agrees with the finding of (Kustyorini 2021).

Leaf Area Index

The effect of urea fertilization on the hydroponically grown maize fodder's leaf area index is shown in (Table 1). The leaf area index of hydroponically grown maize fodder is significantly affected by urea treatment ($P < 0.05$). Treatment 2 had the highest leaf area index (9.92 cm^2), and treatment 3 produced the average leaf area index (8.07 cm^2). After treatment with 0.5 per cent urea, the leaf area index value started to decline while the urea concentration rises. This could be due to the synergistic effect of cytokinin, which promotes plant tissue production and growth at an ideal concentration of 0.5 per cent urea application. This result is superior to the experimental finding of Latha, (2018), which is 7.88 cm^2, the highest finding at a urea application level of 0.5 per cent.

But similar trend was observed with Latha, (2018) which states that leaf area index declines when urea treatment level increased beyond 0.5% level of application. The results of this study are in agreement with Mohidin (2015) who reported leaf area at nitrogen level (100 mg ltr-1) was significantly higher (383.16 cm^2) and begin to decline significantly as the nitrogen level was raised to 300 mg ltr-1 of the oil palm seedlings in solution culture.

Plant Height

The impact of urea fertilizer on the plant height of hydroponic maize fodder is depicted in (Table 1). Urea treatment has significant ($P < 0.05$) effect on plant height. Treatment 2 produced the highest result for plant height (22.06 cm). The plant height was 19.40 cm at the third level (1 per cent) of urea treatment, and it thereafter drops as the amount of urea treatment rises. The plant height increased from 16.98 cm at 0 per cent urea treatment to 22.06 cm at 0.5 per cent urea treatment. When urea levels raises to 1%, 1.5%, and 2%; plant height declined to 19.40 cm, 15.46 cm, and 10.74 cm respectively. The highest plant height of 22.06±0.52cm was observed in this experiment's treatment 2 could be attributed to the plants' optimal nitrogen content, which promotes vegetative development. Furthermore, as the urea content gradually increased, plant height decreased. This could be due to urea's negative effects at higher concentrations. Nutrients are useful for stimulating plant growth, increasing node growth, resulting in an increase in plant height. Plants will grow well if they are encouraged by the application of nitrogen fertilizers at 0.5% to support their growth and development.

The observed results for plant height at each level of urea treatment are better than those from Latha, (2018) experiment, which showed a result of 17.15±0.06 cm at the 0.5 per cent level of urea treatment. According to the report by Latha, the plant height at the 0 per cent urea treatment was 15.13±0.03 cm, which is less than the outcome (16.98±0.56 cm) attained in this experiment. Results are better at the urea treatment levels of 1 and 1.5 per cent, but at the 2 per cent level, the plant height is still less than Upreti et al., (2020) result (12.35±0.01cm). In 11 days of growth, hydroponic maize fodder reaches a height of 27.65±0.34 cm.

However, Kustyorini (2021) showed that hydroponic maize fodder treated with 0% and 5% concentrations of sheep urine had maximum plant heights of 31.6 cm and 29.8 cm, respectively; which is superior to the highest result (22.06±0.52cm) observed in treatment 2 (0.5% urea solution) of this experiment. As a result, nutrients are helpful for promoting plant development and node growth, which together improve plant height. If nitrogen fertilizers are applied to support the growth and development of plants, they will flourish (Latha, 2018). When high concentration fertilizers are applied, yields will improve to a point, but when concentrations are exceeded, yields will fall. Additionally, plants will develop effectively if nutrients are supplied in a balanced amount and in line with the needs of the plant(Kustyorini 2021).

Table 1. Effect of urea application on agronomic characteristics of hydroponic maize fodder

Urea level (%)	Parameters for agronomic characteristics		
	Average leaf number	**Leaf area index (cm²)**	**Plant height (cm)**
T1(control)	3.14±0.05[bc]	7.77±0.32[b]	16.98±0.56[bc]
T2	3.56±0.02[a]	9.92±0.33[a]	22.06±0.52[a]
T3	3.28±0.05[ab]	8.07±0.59[ab]	19.40±0.81[ab]
T4	2.88±0.05[cd]	5.78±0.53[c]	15.46±0.14[c]
T5	2.64±0.18[d]	3.30±0.18[d]	10.74±0.85[d]
SEM	0.20	0.94	1.41
P value	< 0.001	< 0.001	< 0.001

[a,b,c, d] Means with different letter in the column are significantly different ($P<0.05$)

Shoot to Root Ratio

The shot to root ratio measures how much of the fresh hydroponically grown maize feed is made up of shoots and roots. The stalk and root portions of the fodder were separated after the fodder cake had been weighed. After that, the root and shoot were given distinct weight. It is displayed as a percentage after being measured using a balance scale.

The impact of urea fertilization on the shoot to root ratio of hydroponically grown maize fodder is shown in (Table 2). Urea treatment has a significant ($P < 0.05$) effect on shoot to root ratio of hydroponic maize fodder. The highest shoot to root ratio (1.07: 1.65) or 39.34: 60.66 per cent, as the result shows, was recorded at treatment 2 (urea treatment dose of 0.5 per cent). The shoot to root ratio was (0.94:1.75) or 34.94:65.06 per cent at a 0% level of urea application, and it is (0.88:1.50) or 36.97:63.03 per cent at a 1% level of urea treatment. When urea levels rise to 1.5 per cent and 2 per cent respectively; the shoot ratio fall to 30.49 per cent and 26.14 per cent. The highest shoot to root ratio (1.07:1.65 or 39.34:60.66%) obtained at treatment 2 might due to the higher plant height and vegetative percentage, the HMF treated with 0.5 per cent urea has a higher shoot percentage.

The shoot to root ratio was considerably greater at a urea treatment level of 0.5 to 1.5 per cent than Jemimah (2022)'s finding, which ranges from 33.33 to 66.67 per cent. However, the shoot ratio is still below the results of the study by Jemimah (2022) at a 2 per cent dose of urea treatment. This outcome is also better than that of the Naik, et al. (2017) study, which had a 31.69 per cent shoot to 68.32 per cent root ratio. Because root mat and seeds are present, hydroponic maize fodder has a greater root biomass (Jemimah 2022). The number of leaves on a plant affects its yield and growth because they serve as a site for photosynthetic processes that generate the energy required for a plant's growth. Additionally, the number of leaves is correlated with plant height since more leaves form on taller plants (Kustyorini 2021).

Table 2. Effect of urea fertilization on shoot to root ratio of hydroponic maize fodder

Urea level (%)	Total Fodder Wt. (kg)	Shoot Weight (kg)	Root Weight (kg)	Shoot in %	Root in %
T1(control)	2.69±0.12[a]	0.94±0.04[a]	1.75±0.07[a]	34.94	65.06
T2	2.72±0.10[a]	1.07±0.03[a]	1.65±0.05[a]	39.34	60.66
T3	2.38±0.24[a]	0.88±0.09[a]	1.50±0.10[ab]	36.97	63.03
T4	1.64±0.10[b]	0.50±0.03[b]	1.14±0.07[b]	30.49	69.51
T5	1.53±0.16[b]	0.40±0.04[b]	1.13±0.12[b]	26.14	73.86
SEM	0.35	0.12	0.23		
P value	< 0.001	< 0.001	< 0.001		

[a,b,c] Means with different letter in the column are significantly different ($P<0.05$)

Biomass Yield

Fresh Yield

The impact of urea fertilization on the fresh biomass production of hydroponic maize fodder is shown in (Table 3). The fresh yield of hydroponic maize fodder was significantly affected by urea treatment ($P < 0.05$). The level of urea treatment that produced the highest fresh fodder yield (2.71kg/tray) was 0.5 per cent. About 2.65 kilograms of fodder were produced by a tray treated with 0 per cent urea, while 2.38 kilograms of fodder are produced by trays treated with 1 per cent urea. At 1.5 per cent and 2 per cent levels of urea treatment, the yield falls to 1.64 kg and 1.53 kg, respectively. The highest biomass yield of 2710±94.34g/tray (36.8kg/m^2) observed in treatment 2 could be attributed to the additive effect of 0.5% urea on growth assimilates, which resulted in increased plant metabolism, tissue development, dry matter accumulation, and, ultimately, increased biomass yield.

The yield per m^2 is also computed, as shown on (Table 3). The tray was 32 cm long and 23 cm wide. It was 736 cm^2 in size, and the yield per m^2 was derived by dividing 10,000 cm^2 by 736 cm^2, then multiplying the result by the yield per tray. Within a 1 square meter area, hydroponically grown maize fodder might be generated in amounts of 36kg, 36.8kg, and 32.4kg using 0, 0.5, and 1 per cent levels of urea treatment. The fodder production per square meter falls to 22.3 kg and 20.8 kg respectively, when the urea content rises to 1.5 per cent and 2 per cent.

The Jemimah et al. (2020) research result, which is 24.06±1.08 kg/m^2, is outperformed by the results obtained at a 0 to 1 per cent level of urea treatment. The results concur with those of an experiment conducted by Assefa et al. (2020)BH660, BH661, and MVFG (unknown variety as local check, which examined a seed rate of 7.6 kg per square meter and found a fodder density of 33.41 kg/m^2. He also discovered that the BH540 seed type generated 38.03kg of feed per square meter.

Similar results were found in the study by Baral et al. (2021), which investigated the production of 28.09±0.55 kg of hydroponic maize feed from 7 kg of seed on a 1 m^2 area. This outcome is noticeably less than what this experiment produced. Fresh yield and DM content of hydroponic fodder are primarily influenced by the type of crops, days of harvesting, degree of free water drainage before weighing, type and quality of seed, seed rate, seed treatment, water quality, pH, irrigation frequencies, nutrient solution used, light, growing period, temperature, humidity, clean and hygienic condition of the greenhouse, etc. (Naik et al. 2015a).

The highest biomass yield of 2710±94.34 grams (36.8 kg/m^2) observed in urea applications at 0.5 per cent levels may be attributable to the additive effect of urea on growth assimilates, which in turn increased plant metabolism and led to tissue development, dry matter accumulation, and ultimately increased the biomass yield (Latha, 2018).

Seed to Yield Ratio

The influence of urea treatment on the seed to feed ratio of hydroponic maize fodder is shown in the (Table 3). The seed to feed ratio of HMF is significantly ($P<0.05$) impacted by urea. Each growing tray contained 500 grams (0.5 kg) of maize seed, and the production of fresh feed was calculated as indicated in the table. In the end, the weight of fodder generated per kilogram of seed was used to compute the seed to feed ratio. The application of 0.5 per cent urea produced the highest seed to feed ratio (1:5.42), and the urea untreated hydroponic maize fodder produced the second-highest record (1:5.30). This means that with urea treatments of 0.5 per cent and 0 per cent, respectively, 1 kilogram of maize seed can yield 5.42 and 5.30 kilograms of fresh hydroponic maize fodder. 4.76 kilos of fresh HMF may be produced at a 1 per cent level of urea application, but at 1.5 per cent and 2 per cent levels, the yield falls to 3.28 kilograms and 3.06 kilograms, respectively.

In comparison to the results examined by Shanmugam et al. (2018), Jemimah et al. (2020), and (Kammar et al., 2019), which are 4.14, 4.6, and 4.5 kilos/1 kilogram seed correspondingly, the highest result, 5.42 kilograms of fodder per 1 kilogram seed, is superior. However, Kide et al. (2015) reported a biomass yield of 8 kg of hydroponic maize fodder (African tall maize variety) per kilogram of seed when 500 grams of seeds were soaked in tap water for 12 hours, germinated for 24 to 36 hours in gunny bags, and then spread to grow in trays that were 2 square feet in size**.** According to Jemimah et al (2020), 1 kilogram of seed generated 5.26 kg of fresh hydroponic maize feed. Naik et al. (2017) also noted that at seed rates of 7.6 kg and 5.1 kg per square meter, respectively, 5.07 and 5.14 kilograms of hydroponic maize feed were generated from 1 kilogram of seed. A unit of maize seed produced 7 kg of fresh hydroponic maize fodder, according to Barwant (2019). A kilogram of seed yields 4.82 kilograms of fresh HMF according to Murthy et al. (2017), while Adekeye et al. (2020) also reported 4.66 kilograms, 4.29 kilograms, and 4.08 kilograms after treating nutrient solution, borehole water, and fish hatchery waste water, respectively.

Total Dry Matter Yield

The influence of urea treatment on the dry yield of hydroponic maize fodder is shown in (Table 3). Total dry matter yield was affected significantly ($P < 0.05$) by urea treatment. The table demonstrates that the partial dry matter content of HMF raised as urea treatment increases. The level of urea treatment that produced the maximum dry matter (20.21 per cent) was 2 per cent. The partial dry matter content is 16.23 per cent with a urea treatment level of 0 per cent, rising to 16.87 per cent, 17.03 per cent, and 17.34 per cent for urea treatment levels of 0.5 per cent, 1 per cent, and 1.5 per cent, respectively. The dry yield per tray or square meter decreases after a level of urea treatment of 0.5 per cent because the total fresh yield decreased when urea was added above that level. This is true even though the proportion of dry matter increases. The lower % partial DM of maize hydroponic fodder may be due to the large uptake of water initiates increasing metabolic activity of resting seeds leads to complete loss of dry weight (starch) during germinating cycles of hydroponic fodder (Kide, 2017). An increase in fresh production of hydroponic maize fodder is accompanied by an increase in dry production.

This outcome is consistent with studies by Jemimah et al. (2020) and Gebremedhin (2015), which found that the yields were respectively 16.58 per cent and 18.25 per cent without the use of any fertilizer. However, Rahman et al. (2020) demonstrate that 27.95 per cent (764.62 gram dry feed from 2736 grams of sprout HMF) dry matter content; which is superior to the outcome of this experiment. Naik et al.(2016) likewise identified 18.30 per cent dry matter content. The outcome of this trial was better than that of Assefa et al. (2020)BH660, BH661, and MVFG (unknown variety as local check, which was 12.14 per cent DM for BH540.

The reduced percentage of dry matter (DM) in maize hydroponic fodder may be caused by the significant uptake of water, which increases the metabolic activity of dormant seeds and causes a full loss of dry matter (starch) during hydroponic fodder germination cycles (Kide et al. 2015). The difference in growth rate, which is correlated with the pace at which starch stored in the seed is converted into a simple sugar that releases energy together with carbon dioxide and water, may be the cause of the variation in DM percentage of hydroponic fodder (Assefa et al., 2020)BH660, BH661, and MVFG (unknown variety as local check.

Table 3. Effect of urea fertilization on fresh biomass yield, seed to feed ratio and dry biomass yield of hydroponic maize fodder

Urea level (%)	Seed used/tray (kg)	Fresh yield (grams/tray)	Seed to feed ratio	Partial dry matter (%)	Dry yield (kg/tray)	Fresh yield (kg/m^2)	dry yield (kg/m^2)
T1 Control (0)	0.5	2650±101.98^a	1:5.30	16.23±0.02^c	0.43±0.02^a	36.0 kg	5.81±0.22^a
T2 (0.5)	0.5	2710±94.34^a	1:5.42	16.87±0.08b^c	0.46±0.02^a	36.8 kg	6.23±0.21^a
T3 (1)	0.5	2380±146.98^a	1:4.76	17.03±0.04^b	0.40±0.04^{ab}	32.4 kg	5.49±0.56^{ab}
T4 (1.5)	0.5	1640±107.70^b	1:3.28	17.34±0.08^b	0.29±0.02^c	22.3 kg	3.85±0.24^c
T5 (2)	0.5	1530±167.33^b	1:3.06	20.21±0.07^a	0.31±0.03^{bc}	20.8 kg	4.21±0.45^{bc}
SEM		346.27	0.69	0.47	0.06	0.54	0.82
P-value		< 0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001

^{a,b,c} Means with different letter in the column are significantly different (P<0.05)

4. Conclusion

Hydroponic system of fodder production improves the nutritional values of maize fodder; but treating it with nutrient solution is highly expensive. This experiment tried to use urea solution as a nutrient source for hydroponically grown maize fodder and the result obtained is promising to improve the yield and nutritional quality with a minimum cost of production. The agronomic characteristics including leaf number, leaf area index, plant height and shoot to root ratio of hydroponic maize fodder were better at 0.5% level of urea treatment. Yield parameters including fresh yield, seed to feed ratio and dry yield were also recorded high at 0.5% level of urea treatment.

It could be concluded that urea application at 0.5% concentration (5 gram of urea in 1000 ml of water) is optimum for hydroponic maize production as it is believed to favour the cell division, maintains the higher auxin and cytokinins levels which stimulate the cell elongation along the main axis leading to better growth and finally enhances the biomass yield.

Author Contributions

NG, YK and YT prepared the manuscript and preparing the final version of the manuscript and correspond to the journal.

Ethical Approval

This article does not contain any studies involving human or animal participants performed by any of the authors.

Conflicts of Interest:

The authors declare no conflict of interest.

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