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EFFECT OF VARIETY AND SEED RATE ON HYDROPONIC MAIZE FODDER BIOMASS YIELD, CHEMICAL COMPOSITION, AND WATER USE EFFICIENCY

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Abstract: Maize varieties BH540, BH660, BH661, and MVFG (unknown variety as local check) were evaluated at low (5.6 kg m^{-2}), medium (7.6 kg m^{-2}), and high (9.6 kg m^{-2}) seed rate for hydroponic fodder productivity. A 3 × 4m wide and 3 m height low-cost plastic house made of translucent plastic and a plastic trays made by bisecting a 25 liter capacity plastic oil container into two equal parts were used for growing the hydroponic fodder. The bottoms of the trays were drilled to open holes to drain excess water during irrigation and placed on shelves.The BH661 exhibited significantly ($p<0.01$) higher dry fodder yield (6.63 kg) per square meter and per kg seed than the other varieties. Among the seed rates, the high seed rate has a higher ($P< 0.01$) Dry Mater (DM) fodder yield, but the medium and low seed rates had greater DM fodder conversion efficiency and lower cost per kg DM fodder production. Water use efficiency was lower for BH540 (64 kg DM fodder per cubic meter water) as compared to the other varieties that had similar values (90 to 95kg DM fodder per cubic meter water). Medium and high seed rates exhibited similar water use efficiency, and it is higher than the low seed rate. Therefore, the use of BH661 variety at medium seeding rate is recommended for maize hydroponic fodder production.

Key words: maize, sprout, variety, hydroponic

Introduction

According to the Central Statistical Agency of Ethiopia *(CSA, 2018)*, improved forage covers only 0.32% of the total feed resources under the smallholder production system. Conventional forage production practices in Ethiopia and elsewhere have been constrained by many factors. Long dry period, unavailability of water for irrigation and competition for land with food crop production are some of the challenges that make the use of improved forage crops still at its low level *(Yayneshet, 2010; Naik et al., 2013)*. As a result, hydroponic fodder production technology has been advocated as a solution in order to overcome the challenges faced by conventional green fodder production and for climate change adaptation *(Muthuramalingam et al., 2015; Saidi and Omer, 2015)*.

However, *Sneath and McIntosh (2003)* and *Dung et al. (2005)* argued that profitable use of sprouting grain as a feed source for commercial cattle production to appear unlikely due to a reduction in dry matter (DM) weight and increase in cost as a result of sprouting. Nevertheless, some other authors noted that it is the ultimate animal performance relative to the alternative costs that determine the profitability and usefulness of hydroponic fodder *(Muela et al., 2005)*. Although such dialogue exists among authors, hydroponic fodder production technology was introduced in some parts of Ethiopia without any preliminary study.

The survey conducted in northwestern part of Ethiopia after four years of its introduction showed that production was based on low-cost hydroponic unit with barley seed and nutrient solution *(Getachew et al., 2018)*. The average cost of a kg of barley seed and a liter of nutrient solution was 0.37 and 3.72USD, respectively. Even though about 75.7% of the materials needed for hydroponic fodder production are available in the area at an affordable price, almost all respondents have the feeling to quit producing hydroponic fodder production because of the high cost of barley seed indicating that searching for an alternative low-cost cereal seed is required.

The cost of maize (*Zea maize*) is much less than barley in Northwestern part of Ethiopia. Maize has also been used by Indian farmers for hydroponic fodder production *(Naik et al., 2015)*. Studies *(Naik et al.,2015, Weldegerima et al., 2015)* showed that about 6 kg of fresh fodder per kg seed with crude protein (CP) content of 13.57 and water efficiency of 1.7 to 4, in as fresh basis, or 0.22 to 0.60 DM fodder per liter water was produced from a kg of maize grain in India. Similarly, barley produced 4.1 to 6.55kg fresh fodder per kg seed with CP content of 9.16 to 13.2% *(Emam, 2016)* and water efficiency of 1.55, in as fresh basis, or 0.11 kg barely fodder per kg water *(AI-Karaki, and AI-Hashimi, 2012)*.

However, the variety of maize available and the environment (especially humidity) differs between countries requiring the evaluation of hydroponic fodder production from different varieties under the prevailing natural environment. Therefore, the present study is conducted to evaluate the potential of locally available maize varieties for hydroponic fodder production at different seed rates on biomass yield, chemical composition, water use efficiency, and cost of production.

Materials and Methods

Experimental Site. The experiment was conducted at the University of Gondar, Atse-Tewodros campus located at 12°36' N latitude, 37°28' Longitude *(Worldatlas, 2016)* and at an altitude of 2133 meter above sea level. The average annual rainfall of the area is 1772 mm and average annual minimum and maximum temperatures are12.3ºC and 26.4ºC, respectively*(NMA, 2013)*.

Hydroponic System and Fodder Production. Hydroponic fodder was produced in 3 × 4m low-cost plastic house (greenhouse) made of translucent plastic. Plastic trays with 46 cm length, 23cm width, and 8cm depth were made by bisecting a 25L capacity plastic oil container into two equal parts. The bottoms of the trays were drilled to open holes at thirteen points to drain excess water from irrigation. The trays were placed on shelves made of eucalyptus tree timber.

Three widely cultivated varieties of maize (BH660, BH661 and BH540) were used. An unknown, possibly mixed variety of maize available in the local market was used as a check. After cleaning the foreign materials the seed of each variety were weighed as per the treatment plan, i.e., low seed rate (5.6 kgm^{-2}), medium (7.6 kgm^{-2}), and high (9.6 kgm^{-2}). Seeds were sterilized by soaking in a 1% sodium hypochlorite solution (household bleach) for one hour separately. Planting trays and other equipments were also cleaned and disinfected with similar solution of 1% sodium hypochlorite. Then the seeds were washed and soaked in tap water (1.5 mlg^{-1} sample) for about 12 hours. We did not find literature on seed to water ratio for soaking. From our preliminary trial conducted, we found that about 1.2 ml water per gram of seed is required to fully submerge the seed in water during soaking. Since maize absorbs 30% of its weight water before germination *(Shaban, 2013)*, we soaked 1 gram of seed with 1.5 ml water. After washing, the seeds were placed in a cotton cloth bag; water was sprinkled over it and kept for about 24 hours to initiate the emergence of radicles. Then the seeds were sown in a plastic tray as mentioned earlier and tap water was sprinkled over the seedlings four times a day. The seedlings were grown for seven days and harvested. This study was conducted in a 4 × 3 factorial experiment in a Complete Randomized Block Design (CRBD) with three replications, considering the position of a tray on a shelf as a block.

Fodder Biomass and Chemical analysis. In the morning of the eight day of growing fodder biomass yield was measured by difference (the weight of the tray with the fodder – the tray weight). The fodder cake were dismantled and mixed to take a representative sample. The feed conversion efficiency was measured by dividing the weight of hydroponic fodder produced by weigh of seed used. Representative fresh samples were weighed and air-dried in a well-ventilated room spreaded on plastic sheet. After air drying, each replicated sample were weighed, packed in a labeled polyethylene bags, dried in the oven at 60 ^{O}C for 72 hours, milled in a Wiley mill at 1 mm sieve size. The samples were then chemically analyzed.Dry matter, nitrogen (N), and ash were determined using the standard procedures of *AOAC (2005)*. Crude protein (CP) was calculated as N x 6.25. Organic matter was calculated by subtracting ash from 100%. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined following the standard procedures of *Van Soest and Robertson (1985)*. Calcium, phosphorus, potassium, and magnesium were determined by Atomic Absorption Spectrophotometer following Perkin-Elmer AAS 2380procedure *(Perkin-Elmer, 1996)*.Sulfur was determined using Turbidimetric method after digestion with HNO_3-$HCLO_4$ *(Tabatabai and Bremner, 1970)*.

Water use efficiency measurement. Throughout the experimental period, the total water added to and drained out of the trays was recorded every day to compute the total water use and water use efficiency. The total water used by plants (liters/tray) was computed as Total water use = Total added water in irrigation − Total drained water out of the trays *(FAO, 1982; AI-Karaki and AI-Hashimi, 2012)*. Water use efficiency (WUE), kgm^{-3} was computed by the following equation:

$$\text{WUE} = \frac{\text{Total green fodder produced (kg/tray)}}{\text{Total water used (liter/tray)}}$$

Production cost of maize hydroponic fodder. The costs considered for hydroponic fodder production were seed, water, chemical, and material (i.e. depreciation of materials for hydroponic fodder unit and other materials like perforating needle, Jeri can, plastic tray and saw blade). The cost for seed, water and chemical was taken from the information collected from the respondents during the survey conducted by *Getachew et al. (2018)*. The depreciation of materials was estimated based on the material cost and their life span. The total yearly depreciation was divided to the number of days in a year (365) and the result multiplied by 8 to find depreciation per production cycle. Labor was not included in cost analysis since smallholder dairy farms practiced as a part-time activity with family labor. The total cost was tested for sources of costs, cost per varieties, and seed rates.

Statistical Analysis. The data were analyzed using SAS (2009) and when the existence of difference between treatment means was declared, Tukey's multiple range test was employed to detect differences between treatments. The model used for data analysis was $Yijk=\mu +Bi+Vj+Sk+(VjSk)+\varepsilon ijkl$; where:Yijk = an observation in block i, variety j and seed rate k; μ = the overall mean; Bi=Block effect; Vj= the effect of Variety j; Sk= the fixed effect of seed rate k; (VjSk) = Interaction effect of variety and seed rate and εijkl = random error.

Results

Fodder biomass yield. Maize fresh hydroponic fodder biomass yield varied significantly ($p<0.01$) among varieties and seed rates (Table 1). The variety BH661 has the highest and that of the check (MVFG) has the lowest fodder yield ($p<0.05$). The fresh and dry fodder yield increased with increasing seed rate. Contrary, fodder conversion efficiency decreased ($p < 0.01$) with increasing seed rate. Interaction between variety and seed rate was not evident for all parameters. Fresh biomass yield showed a variation of 3.85 (BH660) to 5.03 (BH540) and 4.40 (medium seed rate) to 4.47 (high seed rate).The variations on DM basis were 0.61 (BH540) to 0.88 (BH661) and 0.68 (high seed rate) to 0.74 (medium seed rate).

Table1. Biomass of maize hydroponic fodder yield as affected by variety and seed rate

Parameter	Fodder yield (kgm^{-2})		FCE (Fodder weight/seed weight)	
	Fresh	DM	Fresh	DM
Variety				
BH540	38.03^{a}	4.58^{c}	5.03^{a}	0.61^{c}
BH660	29.29^{b}	5.59^{b}	3.85^{b}	0.74^{b}
BH661	37.78^{a}	6.63^{a}	4.95^{a}	0.88^{a}
MVFG	29.93^{b}	4.82^{c}	3.92^{ab}	0.64^{c}
SEM	1.23	0.23	0.15	0.03
Seed rate (kgm^{-2})				
5.6 (Low)	24.92^{c}	4.11^{c}	4.45	0.74^{a}
7.6 (Medium)	33.41^{b}	5.60^{b}	4.40	0.74^{a}
9.6 (High)	42.94^{a}	6.50^{a}	4.47	0.68^{b}
SEM	1.23	0.23	0.15	0.03
P-value				
Variety	***	***	***	***
Seed rate	**	***	ns	**
Variety× seed rate	ns	ns	ns	ns

$^{a-c}$Means with different superscripts within column and under variety or seed rate differ significantly; **P<0.01; ***P<0.001; ns = non significant; FCE=Fodder conversion efficiency; DM= Dry matter; SEM=Standard error of mean.

Chemical composition. Chemical composition of the hydroponic fodder was unaffected by the interaction of variety and seed rates ($p>0.05$; Table 2). Among varieties, BH540 has the lowest (12.14%) and BH660 has the highest (19.23%) DM content.The high seed rate has lower DM content than the other seed rates that had similar DM content. The maize varieties differ ($p< 0.01$) in their CP content and ranked BH661>BH540>BH660>MVFG. The low seed rate has significantly higher CP content than medium and high seed rates. The NDF content differs only between BH540 and MVFG. There was no significant difference among seed rates in NDF content. The ADF content of the varieties ranked BH540>BH661>BH660 ($p<0.05$); while the value for MVFG was similar with BH540 and BH661 ($p>0.05$). The medium seed rate has significantly higher ADF content than low seed rate, while the high seed rate has similar value with other seed rates.

The ADL content did not differ among varieties ($p>0.05$), while for seed rate ADL content was in the order of medium>low>high ($p<0.05$). Varieties BH660 (4.25%) and BH661 (4.23%) had significantly higher EE content compared to BH540 (4.08%) and MVFG (4.02%). The medium seed rate has lower EE content than low seed rate but was similar with the EE content of the high seed rate. The P and K content of the varieties were similar, while the contents of Ca differed among varieties. The low and high seed rates had significantly higher mineral contents than the medium seed rate.

Table 2. Chemical composition of maize hydroponic fodder

Parameter	DM	Ash	CP	NDF	ADF	ADL	EE	Ca	P	K
Variety	(%)	------------------ (as%DM) ------------------------						------- ($gkg^{-1}DM$) -------		
BH540	12.14^{d}	2.60	10.37^{b}	36.28^{a}	12.17^{a}	1.50	4.08b	1.81^{a}	4.79	5.00
BH660	19.23^{a}	2.54	9.90^{c}	32.67^{ab}	6.89^{c}	1.65	4.25a	1.75^{ab}	4.73	4.94
BH661	17.72^{b}	2.43	10.93^{a}	35.41^{ab}	9.27^{b}	1.44	4.23a	1.64^{b}	4.62	4.83
MVFG	16.23^{c}	2.45	8.01^{d}	31.65^{b}	10.96^{ab}	1.45	4.02b	1.66^{ab}	4.64	4.63
SEM	0.26	0.10	0.20	1.75	0.85	0.23	0.03	0.08	0.08	0.57
Seed rate$^{\Theta}$										
5.6 (Low)	16.77^{a}	2.70^{a}	10.13^{a}	32.82	8.79^{b}	1.5^{b}	4.18^{a}	2.35^{a}	5.33^{a}	5.37^{a}
7.6 (Medium)	16.95^{a}	2.07^{b}	9.49^{b}	35.32	10.97^{a}	2.18^{a}	4.11^{b}	0.42^{b}	3.40^{b}	3.61^{b}
9.6 (High)	15.27^{b}	2.74^{a}	9.78^{b}	33.87	9.71^{ab}	0.77^{c}	4.14^{ab}	2.39^{a}	5.37^{a}	5.58^{a}
SEM	0.26	0.10	0.20	1.75	0.85	0.23	0.03	0.08	0.08	0.57
P value										
Variety	***	ns	***	***	***	ns	***	**	ns	ns
Seed rate	***	***	**	ns	**	***	**	***	***	***
Var. × SR	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

$^{a\text{-}d}$Means with different superscripts within column and under variety or seed rate differ significantly;**P<0.01; ***P<0.001; ns = non significant; CP= Crude Protein; NDF= Neutral Detergent Fiber; ADF= Acid detergent Fiber; ADL= Acid Detergent Lignin; EE= Ether extract; Ca =Calcium; P= Phosphorus; K= Potassium; SEM=Standard error of mean; Θ = Seed rate is kgm^{-2}.

Water use efficiency. The water consumption of maize varieties hydroponic fodder ranged from 1.83 (MVFG) to 2.07 (BH660) liter per kg fresh fodder produced or 10.62 (BH661) to 15.71(BH540) liter per kg DM fodder (Table 3).

Table 3.Water use efficiency of maize hydroponic fodder as affected by variety and seed rate

Parameter	Total water use			Water use efficiency	
	Liters/tray	Liters/kg fresh fodder	Liters/kg DM fodder	Fresh fodder (kgm^{-3})	DM fodder (kgm^{-3})
Variety					
BH540	7.82^{a}	1.91^{b}	15.71^{a}	531.41^{ab}	64.22^{b}
BH660	6.47^{b}	2.07^{a}	10.74^{b}	491.70^{b}	94.19^{a}
BH661	7.60^{a}	1.88^{b}	10.62^{b}	539.91^{a}	95.23^{a}
MVFG	5.78^{b}	1.83^{b}	11.22^{b}	561.34^{a}	90.66^{a}
SEM	0.20	0.07	0.53	19.64	3.36
Seed rate (kg/m2)					
5.6 (Low)	6.07^{c}	2.23^{a}	13.61^{a}	450.34^{c}	75.02^{b}
7.6 (Medium)	6.92^{b}	1.88^{b}	11.46^{b}	533.74^{b}	90.39^{a}
9.6 (High)	7.77^{a}	1.65^{c}	11.15^{b}	609.20^{a}	92.81^{a}
SEM	0.20	0.07	0.53	19.64	3.36
P- value					
Variety	***	**	***	**	***
Seed rate	***	**	***	***	***
Variety X seed rate	ns	ns	ns	ns	ns

$^{a-c}$Means with different superscripts within column and under variety or seed rate differ significantly; **$P<0.01$; ***$P<0.001$; ns = non significant

The water use efficiency of maize varieties hydroponic fodder ranged from 491.70 (BH660) to 561.34 (MVFG) kg fresh fodder per m^3 or 64.22 (BH540) to 95.23 (BH661) kg DM fodder per m^3 water (Table 3).Water use efficiency of DM fodder was lower in the variety BH540 (64.22 kg m^{-3}) compared to the other varieties that had similar values. The medium and high seed rates had higher ($p< 0.05$) water use efficiencyof DM fodder than low seed rate.

Production cost of maize hydroponic fodder. The total cost of hydroponic fodder production was 34.34 USD per 100kg DM without labor, and labor cost being 0.83 USD per 100 kg DM (Table 4). Seed cost accounted for the highest share of the cost of hydroponic fodder production. Materials depreciation, water, and chemical were the second, third, and fourth source of cost for hydroponic forage production, respectively.

Table 4. Relative cost of maize hydroponic fodder production (per 100kg DM)

Source of cost	Without labor		With labor	
	Cost (USD)	%	Cost (USD)	%
Seed	31.56	91.90	31.56	89.74
Water	0.28	0.82	0.28	0.80
Chemical	0.12	0.35	0.12	0.34
Material	2.38	6.93	2.38	6.77
Labor	-	-	0.83	2.36

When labor is considered, labor cost took third place following seed and material depreciation costs.The less expensive variety for production of hydroponic forage was BH661 and the more expensive variety was MVFG (Table 5). Among seed rates, the medium seed rate has lower ($p<0.05$) cost of production per kg DM fodder when compared with the high seed rate.

Table 5. Maize hydroponic fodder cost of production (WoL) as affected by variety and seed rate

Parameter	Cost per 100 kg fresh fodder (USD)	Cost per 100 kg DM fodder yield (USD)	HpF to Grain Cost ratio
Variety			
BH540	4.55[c]	37.66[b]	2.09[b]
BH660	5.96[b]	31.06[c]	1.73[c]
BH661	4.62[c]	26.11[d]	1.46[d]
MVFG	6.90[a]	42.54[a]	2.37[a]
SEM	0.22	1.47	0.08
Seed rate (kg/m^2)			
5.6 (Low)	5.69	34.34[ab]	1.91[a]
7.6 (Medium)	5.46	32.79[b]	1.83[b]
9.6 (High)	5.38	35.89[a]	2.00[a]
SEM	0.22	1.47	0.08
P-value			
Variety	***	***	***
Seed rate	ns	**	***
Variety x Seed rate	ns	ns	ns

[a-c]Means with different superscripts within column and under variety or seed rate differ significantly; **P<0.01; ***P<0.001; ns = non significant

Changing maize grain to hydroponic fodder increased the cost of feed by 1.46 (BH661) to 2.37 (MVFG) per kg DM for variety and by 1.83 to 2.00 for seed rates. Using variety BH540, MVFG and high seed rate for hydroponic fodder production increased cost by more than double the cost of feed per kg DM. Variety BH661 increased the cost of feed by only 31.51%.

Discussion

The fresh biomass yield productivity (3.85 to 5.03 fold) per initial seed used observed in the present experiment was comparable to that reported by *Naik and Singh (2013)* and *Jemimah et al. (2018)* who obtained 5 to 6 kg and 4.6 kg of hydroponic maize fodder per kg seed used, respectively. *Al-Ajmi et al. (2009)* and *Lamnganbi and Surve (2017)* also reported 2.76 and 5.7 kg green fresh fodder yield per kg of barley seed, which is almost similar with the result obtained in the present work. However, it was less than the value (6 to 10 kg of fodder per kg of maize seed) reported by *Sneath and McIntosh (2003)*. The variation in fodder yield among studies could be attributed to the differences in the varieties of maize used or differences in the extents to which the environmental factor such as humidity and temperature might have been fully controlled since they had used commercial fodder units. The decrease in a DM recovery (fodder conversion efficiency) when seed rate increased from 7.6 kg m^{-2} to 9.6 kg m^{-2} agreed with the report of *Naik et al. (2017).* These authors, also reported that the yield per kg decreases with increase in seed rate.

Considering the total net productive area of the shade (3 × 4m area with three floor shelves that accommodate 126 trays of 0.11m^2) and 8 days cycle of hydroponic fodder production at a productivity potential of 29.29 to 38.03kg m^{-2}, a total of 1.14 to 1.48 tons of fresh hydroponic fodder can be harvested from the present hydroponic system in nine dry months of the area. Under conventional farming, the average fresh forage biomass produced from maize was reported to be 28.43 and 30.67 tons ha^{-1} at planting space of 75 and 35.5 cm, respectively *(Dicu et al., 2016)*, which is equivalent to 2.24 to 3.07 kg m^{-2} of land area. With three cycles a year production, only about 6.84 to 9.21 kg fresh fodder can be produced per m^2 of land under conventional farming indicating high efficiency of hydroponic fodder production in terms of land utilization. Based on the observed productivity in the present experiment, an area of 4 to 6m^2 land is sufficient to produce 10 kg fresh fodder required for a cow per day indicating even such a small size hydroponic fodder units is enough for saving expense on material depreciation and opportunity cost of the space. The area requirement can be reduced if production per unit area is more maximized. In this regard, *Kamanga (2016)* reported that one square meter space was enough to produce fodder for two cows per day.

The DM percentage of hydroponic fodder was comparable with the values of 18.48 %, 16.53 %, and 17.21 to 23.25 % DM content of maize hydroponic fodder reported by *Gebremedhin (2015)*, *Dadhich (2016)* and *Jemimah et al. (2018)*, respectively. Varieties differ in DM content, and the reason for variation among varieties in DM percentage of hydroponic fodder may be due to the difference in growth rate which is also related to the rate of conversion of starch stored in the seed into a simple sugar, which produces energy and gives off carbon dioxide and water *(Bakshi et al., 2017)*.

The CP of hydroponic fodder in this study was comparable with the value (8.72 to 17.55) reported by *Jemimah et al. (2018)* but lower than the 13.3 % reported by *Naik et al. (2014)* and 14.56 % reported by *Gebremedhin (2015)*. The variation may be due to the differences in variety of maize used for hydroponic fodder production. The reduction in dry biomass yield due to changing the grain to hydroponic fodder was also reported by *Sneath and McIntosh (2003)*, *Dung et al. (2010)* and *Putnam et al. (2013)* for different crops. The loss in weight may be due to leaching of soluble carbohydrates and respiration. The conversion of starch stored in the seed by seed soaking activated enzymes in endosperm to a simple sugar produces energy and gives off carbon dioxide and water. This process leads to loss of DM with a shift from starch in the seed to fiber and pectin in the roots and green shoots *(Bakshi et al., 2017)*.

The amount of water required (1.65-2 liter if water is recycled and 2-3.3 liter if water is not recycled) to grow one kg of hydroponic maize fodder reported by *Naik et al. (2013)* agreed with the net water consumption of maize hydroponic fodder in the present experiment (1.52-2.29 l kg^{-1}fresh fodder).Our finding also agreed with the value of 1.5-2 liter of water required per kg fodder reported by *Al-Karaki (2010)*. Under conventional farming 73, 85 and 160 liters of water is required to produce one kg green fodder of barley, alfalfa, and Rhodes, respectively *(Bakshi et al., 2017)*. *Naik et al.(2015)* and *Naik and Singh (2013)* noted that 90% and 90-98%, respectively of the hydroponic fodder production cost is associated with cost of seed, which agreed with the finding of the present study. The cost of pasture grass hay per kg in Ethiopia from 2010 to 2014 was between 0.70 to 4.44 Birr *(Mesfin et al., 2014; Adugna et al., 2014)*; equivalent to 0.02 to 0.14 USD at current exchange rate of 0.031 USD per Birr. Pasture grass hay contains on the average 6.54 % CP (SSAFeed, 2019) and from 6.95 to 9.83 MJ ME per kg DM *(Fekede et al., 2014)*. Hydroponic maize fodder contains 13.23 to 13.31 MJ ME per kg DM *(Getachew et al., 2019)*. This indicates, in terms of CP cost hydroponic fodder is better due to the cost per kg CP as compared to pasture grass hay. A kg CP in hay costs 0.34 to 2.09 USD whereas in hydroponic fodder it is 0.02 to 0.05 USD per kg CP. In terms of energy pasture grass hay costs 0.001 to 0.02 USD per MJ ME as compared to 0.01 to 0.03 US dollars MJ^{-1}ME for hydroponic fodder.

Conclusion

Among the varieties tested BH661 is better for hydroponic fodder production due to higher DM fodder yield with relatively low cost of production. The 9.6 kg seed rate m^{-2} produced higher DM hydroponic fodder m^{-2} and has low hydroponic fodder to grain cost ratio. Nevertheless, its cost per kg DM was high. In comparison to this, seed rate of 7.6 kg m^{-2} is high in its fodder conversion efficiency. Changing maize grain to hydroponic fodder reduced the DM weight of the initial grain and increased the cost of feed per kg DM. This means that hydroponic fodder production *per se* has no yield advantage. However, quality advantage together with its effect on the profitability of livestock production and the need for green fodder under the scenarios of climate change need to be considered to use hydroponic fodder production.

Uticaj sorte i setvene stope na prinos biomase krme hidroponskog kukuruza, hemijski sastav i efikasnost upotrebe vode

Getachew Assefa, Mengistu Urge, Getachew Animut, Getnet Assefa

Rezime

U ovom istraživanju, ispitan je uticaj sorte kukuruza BH540, BH660, BH661 i MVFG (nepoznata sorta kao lokalna provera) u uslovima niske (5,6 kg m^{-2}), srednje (7,6kg m^{-}2) i visoke (9,6kg m^{-}2) količine semena po jedinici površine/setvenoj stopi, na produktivnost hidroponskog krmiva. Za uzgoj hidroponskog krmiva korišćena je jeftina plastična kućišta dimenzija 3×4 i visine 3 m, izrađena od prozirne plastike i plastičnih ležišta napravljenih odvajanjem posude od plastike zapremine 25 litara u dva jednaka dela. Dna ležišta su izbušena da bi se izlivala suvišne voda tokom navodnjavanja i postavile na police. BH661 je pokazao značajno ($p < 0,01$) veći prinos suve krme (6,63 kg) po kvadratnom metru i po kg semena od ostalih sorti. Od svih korišćenih setvenih stopa, visoka stopa je imala veći ($P<0,01$) prinos suve materije (DM), ali srednje i niske stope imale su veću efikasnost konverzije DM krme i nižu cenu po kilogramu proizvodnje DM krme. Učinkovitost upotrebe vode bila je manja za BH540 (64 kg krme po kubnom metru vode) u poređenju s ostalim sortama koje su imale slične vrednosti (90 do 95 kilograma krmiva po kubnom metru). Srednja i visoka količina semena pokazala je sličnu efikasnost upotrebe vode, i viša je od niske setvene stope. Zbog toga se za proizvodnju hidroponske krme za kukuruz preporučuje upotreba sorte BH661 u srednjoj setvenoj stopi.

Ključne reči: kukuruz, izdanci, sorta, hidroponik

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