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NUTRITIONAL COMPARISON BETWEEN HYDROPONICALLY GROWN LEGUMINOUS AND NON-LEGUMINOUS FODDER TO IDENTIFY THE ADAPTABILITY AND BEST HARVESTING TIME FOR SUSTAINABLE HYDROPONIC GRASS PRODUCTION

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Two types of fodder crops were evaluated in this study, maize (*Zia maize*) and black gram (BG) (*Vigna mungo*) and in maize, non-descriptive local maize (LM) and hybrid maize (HM) verity were used. LM was considered as control and changes of the nutritional composition according to the type of fodder (leguminous and non-leguminous) and the day was evaluated. For comparative nutritional analysis, dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF), acid detergent fibre (ADF), neutral detergent fibre (NDF), and total ash were analyzed and the biomass yield was measured using weight balance and root and shoot length of experimental fodders. Results revealed that among three types of forages total DM was significantly ($P<0.01$) higher in HM and significantly ($P<0.01$) lower in BG. Considering total CP and NDF, it was significantly ($P<0.01$) higher in BG and HM than LM. The highest biomass yield and shoot length were observed in BG and the lowest biomass yield was observed in HM. Moreover, with the increment of days, all fodder sprouts DM% was constantly decreasing, however, CP% maintained the same level from day 1 to 5. Although from day 6 to 9, CP% increased moderately for HM and BG, CP% decreased slightly for LM. Therefore, farmer can use BG and HM for maximum utilization of nutrients and considering DM and CP% for LM day 6 was the best time for harvesting; however, for HM and BG, day 9 or more than 9 was the best time for harvesting.

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INTRODUCTION

For sustainable livestock production, green fodder is a prerequisite; however, many reasons are hindering green fodder production. Among them, scarcity of land for fodder production, quality fodder availability, and adverse climate conditions plays a vital role. For mitigating these constraints, hydroponics technology becomes an alternative way to grow fodder for farm animals (Salo, 2019). Hydroponic fodder production technology is an environmental friendly horizontal green fodder production technology where grains were converted into quality fresh fodder within a short period (Ajmi et al., 2009). Different types of grain such asmaize (*Zea mays*), oats (*Avena Sativa*), barley (*Hordeum Vulgare)*, wheat (*Triticumae stivum),* alfalfa (*Medicago sativa*), cowpea (*Vigna unguiculata*), sorghum (*Sorghum bicolor*), black gram (*Vigna mungo L*.) seed can be used for hydroponic fodder production (Masood et al., 2014; Rachel et al., 2018; Ghazi et al., 2012). Moreover, this technology has a 6-7 times higher biomass conversion ratio compared to conventional green fodder production, along with enabling bioactive enzymes, essential fatty acids and minerals by converting complex nutrients into a simple component which is essential for animal growth and proliferation (Naik et al., 2015). Furthermore, Hydroponic is a highly profitable technique for fodder production in some particular areas of Bangladesh (Uddin and Dhar, 2018).

Maize fodder has a positive impact on milk production and it is reported that hydroponically grown maize fodder has a higher nutrient value (crude protein, ether extract, nitrogen-free extract, Ca, Na, K, Mg, Mn and Cu) comparative to the commercially available fodder produced by conventional practices (Zainab et al., 2019). Hence farmers are producing hydroponic maize fodder for increasing feed efficiency and milk composition of cattle (Bari et al., 2020). Different types of maize seed can be used for hydroponic fodder production. In Bangladesh two type of maize is available, one is local and another is hybrid maize, whereas both types of seeds can be used for hydroponic fodder production. Farmers prefer HM for its easy growing and high yield nature (Karim et al., 2010). It is reported that the nutrient quality of hydroponic fodder varies from variety (Assefa et al., 2020). On the other hand, leguminous type of fodders has higher hydroponic fodder productivity per kg of seed and crude protein content than cereal grain (Rachel et al., 2018). Hence,there is a scope for alternating cropping of leguminous fodder using hydroponic technology. However, which type of fodder is more adjustable for hydroponic fodder production is not properly studied. Hence, in this study, a comparative study of leguminous and non-leguminous fodder was conducted using maize and BG to identify suitable seed for hydroponic grass production based on nutrient composition. Nevertheless, harvesting time may have a significant effect on the CP content of hydroponically grown fodder. It is also reported that hydroponic fodder production technology has a positive significant effect on the Mineral and vitamins (vitamin A and E) content of grains (Kide et al., 2015). Most of the hydroponic fodder is harvested from day 5 to day 10 (Salo, 2019). To determine the best harvesting time for maize and BG in this study effect of day on nutritional component was also observed.

MATERIALS AND METHODS

This study was conducted in plant and nutrition laboratory of Biotechnology Division, Bangladesh Livestock Research Institution, Savar, Dhaka- 1341, Bangladesh. A locally made hydroponic system including metal frame and two standing shelves, artificial light with thermometer and hygrometer facility was used in this experiment. Each shelf contained four racks and each rack was able to hold 3 plastic trays and the size of the tray was 2.52 sq. feet. To keep moisture condition manual hand sprayer was used. The average temperature and relative humidity of the room were 21.40˚C and 77.07% respectively.

Plant material

Two types of fodder crops were evaluated in this study which was maize (*Zia maize*) and BG (*Vigna mungo*). Moreover, in maize two verity was used one was local verity (Non-descriptive), used for cultivation of maize fodder and another was hybrid verity (Bangladesh Agriculture Development Corporation- BADC Hybreed maize). All seeds of these crops were obtained from the local market of Dhaka. Before conducting this experiment germination test was conducted for determining the viability of the seed. The result of viability was 79%, 84% and 80% for LM, HM and BG respectively.

Treatment of seeds

Seeds of all crops were separated from debris and other foreign materials. Then the cleaned seeds were sun-dried for 12 hours and subsequently soaked for 30 minutes in a2 % hydrogen peroxide (H_2O_2) solution to control the formation of mould (Shit, 2019). Planting trays were also cleaned and disinfected using chlorine solution.

Seed planting and irrigation

The seeds were washed well and placed into the planting tray lined with plastic sheets and had holes at the bottom to allow drainage of excess water from irrigation. In each tray seeding rates were 2 kg/tray. Subsequently, the clean white moist cloth was used for 24 hours on the germination tray for proper germination of seed. To maintain moist condition, 500ml water/tray/day was sprayed twice a day using a manual hand sprayer.

Proximate analysis

The chemical composition of dry fodder samples was determined according to the standard methods of AOAC (2005). DM and Ash were determined by drying in an oven for 24 hours at 80ºC and ashing samples in a muffle furnace at 500ºC for 24 hr, respectively. CP was determined using a Foss Tecator Kjeltec 2300 Nitrogen/Protein Analyzer. EE was analyzed by Soxhlet extraction of the dry sample using petroleum ether. ADF was determined using cetyltrimethyl ammonium bromide (CTAB) and 1N H_2SO_4. NDF was determined using sodium sulphite and sodium lauryl sulphates. CF was analyzed by FOSS Fibertec system according to Weende van Soest method.

Measuring root and shout length and biomass production

The root and shoot length of experimental hydroponic green fodders were measured using a meter scale on harvesting day. The individual plant was carefully removed from the sprout mat for measurement. The root length was measured from the cuticle to the tip of the longest root segment and the shoot length was measured from the base of the hypocotyls to the tip of the longest leaf. Moreover, for the measurement of biomass production, a 40 kg measuring balance was used. Biomass production was measured on harvesting day.

Experimental design and statics

A completely randomized design with four replicates was used in this study. Local maize was considered as control and the pairwise comparison based on the estimated marginal mean of LM with HM and BG was conducted for determining the best type for hydroponic fodder production. Moreover, to determine the comparative feature of biomass yield, root and shoot length, one-way Analysis of variance (ANOVA) of the same software was used. Duncan's Multiple Range Test (DMRT) of the same software, was used to compare means that were found to be statistically different (Duncan, 2013). The significant difference was tested at a 5% probability level. Moreover, to investigate the impact of day on the proximate component of hydroponic fodder correlation between day and nutritional composition of fodder was determine by using bivariate correlation of the same software. Finally, considering the highest CP content best harvesting time was determined.

RESULTS AND DISCUSSION

Comparison of proximate component and biomass yield

From table 1, it was observed that after harvesting total DM was significantly ($P<0.01$) higher in HM and significantly ($P<0.01$) lower in BG compares to LM. Hence, total DM% was decreased significantly in leguminous comparatively non-leguminous. Hydroponic fodder usually contains 80-85% water and during the 8-10 sprouting cycle, grain losses its dry matter from 10% to 15% due to reduction of starch contain (Ajmi et al., 2009). However, considering total CP and total NDF it was significantly ($P<0.01$) higher in BG and HM than LM. Although highest total CP value was observed in BG (23.206±0.203) which was three times higher than HM. Naturally, the leguminous seed has higher CP than the non-leguminous seed (Ghazi et al., 2012). Hence, in the hydroponic fodder production system, the total CP contains was higher in leguminous fodder. However, between LM and HM, HM contains higher total CP than LM. Due to the hybridization total CP in HM may increase. Considering ADF it was found that, in HM it was significantly lower, although in BG it was significantly higher than the LM. In case of ash content, it was significantly higher in BG and non-significantly lower in HM compare to LM. On the other hand, EE was significantly lower in BG but non-significantly higher in HM. Hence, considering CP and NDF contain for hydroponic fodder production leguminous fodder is superior to non-leguminous fodder.

Table 1. Pairwise comparison of LM with HM and BG

Chemical composition	Varieties	Mean±SE	Mean differences of LM with HM and BG	Sig.[*]
	HM	38.647±0.203	-1.823*	.000
DM	LM	36.823±0.203		
	BG	17.338±0.203	19.486*	.000
	HM	1.810±0.192	0.224	1.00
Ash	LM	2.034±0.192		
	BG	3.398±0.192	-1.364*	.000
	HM	10.090±0.222	1.633*	.000
ADF	LM	11.723±0.222		
	BG	19.846±0.222	-8.122[*]	.000
	HM	7.274±0.203	-1.424*	.000
CP	LM	5.850±0.203		
	BG	23.206±0.203	-17.356*	.000
	HM	23.159±0.202	-2.695*	.000
NDF	LM	20.464±0.202		
	BG	25.016±0.202	-4.553*	.000
	HM	3.150±0.191	-0.036	1.00
EE	LM	3.114±0.191		
	BG	1.594±0.191	1.520*	.000

*The mean difference is significant at the 0.05 level

From table 2, it was observed that there was a significant variation (P<0.01) in biomass yield among three varieties. The highest biomass yield was observed in BG and the lowest biomass yield was observed in HM. It was reported that Leguminous fodder (Cowpea) had higher biomass yield than non-leguminous fodder (Wheat) (Rachel et al., 2018; Ghazi et al., 2012). There was no significant difference in root number, however; there was a significant variation (P<0.01) of root length and shout length. The highest root length was observed in LM whereas the lowest loot length was observed in BG. Considering, shout length highest shout length was observed in BG and the lowest shout length was observed in BG. It was reported that leguminous type fodder contains higher shout length and lower root length than yellow maize (Rachel et al., 2018).

Table 2. Comparative feature of biomass yield, root and shout length

Observation	LM	HM	BG	Sig.
Biomass yield (Kg)	5.07±0.83[a]	4.30±0.78[a]	12.00±1.2[b]	***
Root Number	6.20±0.42	6.00±0.37	6.10±0.48	NS
Root length (Cm)	6.08±0.37[b]	2.87±0.23[a]	2.79±0.21[a]	***
Shoot length (Cm)	7.6±0.42[a]	8.60±0.48[b]	13.3±0.30[c]	***

*** = (P<0.01)

After, proximate analysis from of root and shout it was observed that shout contain a higher amount of CP than root and considering CP ratio of shout and root among three varieties BG was the highest and LM was the lowest (Fig. 1). Shouts of hydroponic fodder contain higher amount of nutrient than root (Vijayakumar et al., 2019). Although, biomass yield was lower in HM, due to higher shout length and lower root length HM may contain higher amount of total CP than LM. Similarly, BG had the highest shoot length consequently total CP was found highest in BG. Hence, among the three types of fodder BG is more potential than LM and HM. Moreover, small root length and high shout lent is desirable for hydroponic fodder production and nutrient content of fodder may increase along with increase shout length.

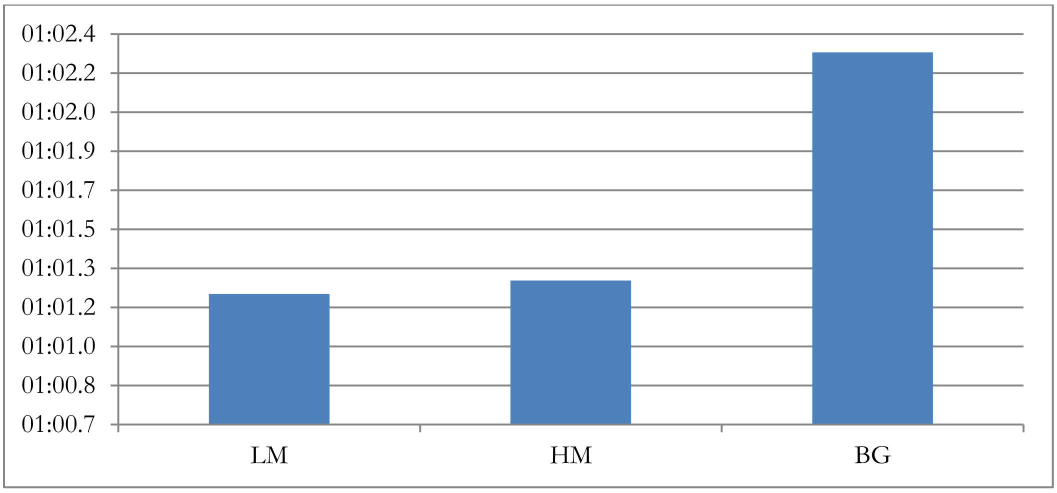

Figure 1. CP ratio root: shout in LM, HM and BG

Table 3. Correlations of type-wise proximate compositions with the increases of cultivation days

Chemical composition	Varieties of Hydrophonic					
	LM		HM		BG	
	Pearson Correlation	Sig. (2-tailed)	Pearson Correlation	Sig. (2-tailed)	Pearson Correlation	Sig. (2-tailed)
DM	-0.939**	.000	-0.905**	.000	-0.822**	.000
CP	-0.128	.499	0.399*	.029	0.766**	.000
ADF	-0.267	.153	-0.662**	.000	0.568**	.001
NDF	0.582**	.001	0.323	.082	0.721**	.000
Ash	0.479**	.007	-0.527**	.003	-0.636**	.000
EE	0.106	.579	0.452*	.012	0.069	.717

** Correlation is significant at the 0.01 level (2-tailed)

Effect of day onthe proximate component of hydroponic fodder

From table 3, it was observed that in all types of hydroponic fodder DM was decreased significantly (P<0.01) with the increase of days. Naki et al. (2015) also reported that in case of all kinds of fodder DM is decreased under hydroponic fodder production system. When DM was decreased, CP% was increased significantly (P<0.05) in HM and BG, although in LM, CP % was decreased. Dung et al. (2005) reported that an increase in CP in sprouts compared to the grain, which may be due to the un-utilization of protein during germination (Dung et al., 2005). Protein is not directly related to germination (Ajmi et al., 2009) and due to a decrease in dry weight CP% may be increased. Along with CP, NDF percentage increased significantly in LM and BG (P<0.01). In BG, ADF% increased significantly (P<0.01) although, ADF was decreased in HM and LM, whereas it decreased significantly (P<0.01) in HM. In HM and BG, ash percentage decreased significantly, but in LM it increased significantly. Moreover, EE % increased in all types of hydroponic fodder and in HM, EE increased significantly (P<0.05). Hence, there was a correlation between day and the proximate component of hydroponic fodder.

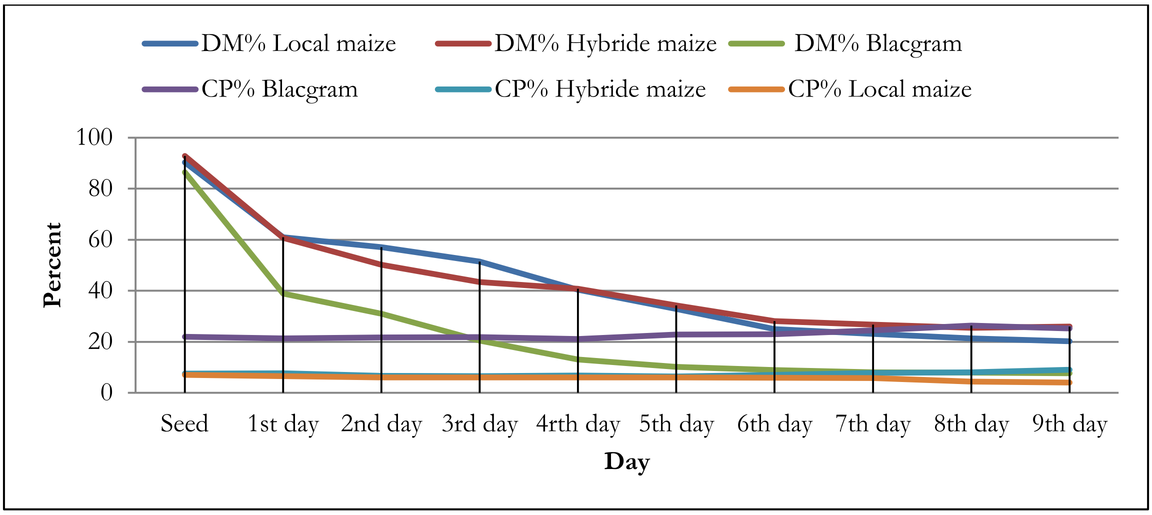

Figure 2. DM and CP contain in different day

From Fig. 2, it is observed that for all type of fodder sprout DM was decreasing constantly from day 1 to day 5. However, from day 6 to day 9 DM was level out. On the other hand, CP % maintained the same level from day 1 to day 5. Although, from day 6 to day 9 CP % increased moderately for hybrid maize and Black gram sprout, although CP % decreased slightly for local maize. Hence, considering DM and CP% for local maize day 6 was the best time for harvesting however, for hybrid maize and Black gram day 9 or more than day 9 was the best time for harvesting. The photosynthesis process during germination is started on the fifth day when the chloroplasts are activated (Al-Karaki and Al-Momani, 2011; Adjlanea et al., 2016). This may prevent the decreasing trend of DM% as well as increasing CP%.

CONCLUSIONS

Considering proximate component and biomass yield using leguminous seed for hydroponic fodder production has higher value than non-leguminous seed. Moreover, considering non-leguminous fodder HM has a higher nutrient value than LM, although biomass yield is lower than LM. High root length may increase the biomass yield of LM. Hence, higher shoot length and lower root length fodder are desirable for harvesting maximum nutrient in the hydroponic fodder production system. Further research will have to be conducted considering other leguminous and non-leguminous fodder and, changes in anti-nutritional factors of leguminous fodder will have to address during the final recommendation.

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CONFLICT OF INTEREST

The authors do not have any conflict of interest.

Authors' contributions

Kabir MA developed the research idea, designed the research, collected, analyzed, interpreted the data and drafted the manuscript. Rakib MRH contributed to conceptualize, coordinate in interpreting the data, writing, reviewing and critical checking of the manuscript. Amin MR greatly contributed to analyze the data and writtiing of the manuscript. Hossain SMJ, Amanullah SM, Deb GK were involved in study design and supervision. Das NG was involved in critical revision of the manuscript.

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