Journal of Agriculture and Natural Resources (2022) 5(1): 27-33
ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
DOI: https://doi.org/10.3126/janr.v5i1.50378

Research Article

Comparison of different cereal grains for hydroponic fodder production in locally constructed polyhouse at Khumaltar, Lalitpur, Nepal

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ABSTRACT

Hydroponic fodder production technology involves an intensive method of quality fodder production in less space and in a shorter duration. An experiment was conducted to compare the different cereal grains under hydroponic fodder production for the fodder yield, fodder quality, and per unit production cost in a locally constructed polyhouse. Maize (*Zea mays* L.), oat (*Avena sativa* L.) and wheat (*Triticum aestivum* L.) were evaluated as the treatments. The experiment was carried out in Completely Randomized Design (CRD) with 12 replications at National Pasture and Fodder Research Program in July 2017 and July 2018. The observations were taken on plant morphological characters, fodder yield (including root mat), fodder nutrient composition and expenses in variable costs. The results of the study showed that the fodder yield varied significantly ($P<0.05$) for different cereal grains. The hydroponic fodder yields from each kg grain were recorded higher in fodder oat (7.96 kg) compared to wheat (6.76 kg) and maize (5.32 kg). Similarly, the crude protein (CP) content of the fodder was higher in wheat (16.16%) compared to oat (13.96%) and maize (12.51%). The cost of hydroponic maize, oat and wheat fodder production were obtained as recorded NPR 20.64, 24.67 and 18.76 per kg, respectively.

Keywords: Fodder yield, plant height, fodder color, nutrient composition, cost of production

Correct citation: Upreti, S., Ghimire, R.P., & Banskota, N. (2022). Comparison of different cereals for hydroponic fodder production in locally constructed polyhouse at Khumaltar, Lalitpur, Nepal. *Journal of Agriculture and Natural Resources, 15*(1), 27-33.
DOI: https://doi.org/10.3126/janr.v5i1.50378

INTRODUCTION

Ruminant livestock farming in peri-urban areas is growing rapidly in Nepal. There is, however, a serious problem with the availability of quality fodder on a year-round basis in those urban peripheries, for commercial ruminant farms. Most of these dairy farmers are adopting straw-based concentrate-supplemented feeding systems; which are neither healthy for those high productive animals nor cost-effective to the farmers.

Hydroponic fodder production technology is being adopted by the ruminant farmers of urban and peri-urban area where the land is limited. It is best suited to land and time-scarce and areas suffering from chronic water shortages or in areas where irrigation infrastructure is difficult (Bakshi, 2018). Recently, hydroponicfodder production technology to grow nutritious and quality fodder within one to two weeks on a year-round basis under closed enclosure in a controlled condition (i.e. temperature and relativehumidity) has been

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developed and being quite popular among the peri-urban farmers in Nepal. Internalizing its importance, this technology is now promoted by Government in Nepal (NAFLQML, 2019).

This fodder production system helps to get regular green fodder to supplement to the crop residues and improve feeding value in the diets. Further, hydroponic fodder help to replace the expensive concentrate feed that ultimately helps to the reductionofthe existing cost of milk production (Upreti *et al.*, 2021).

There are several cereal crops selected as suitable for hydroponic fodder production with different yield potentialsin the reports. Some of them are barley (Reddy *et al.*, 1988), oat and wheat (Snow *et al.*, 2008), sorghum, alfa-alfa and cowpea (Karki *et al.,* 2012) and maize (Naik *et al.*, 2011; Naik *et al.*, 2014). Studies have proved that the nutrient contents and digestibility of hydroponic fodders are superior to certain common cereal and leguminous fodder such as berseem and clover in terms of nutrients availability such as OM, CP, EE and NFE content (Reddy *et al.,* 1988; Pandey & Pathak, 1991; Naik *et al.*, 2012).The need of alternative ways to grow fodder for farm animals has been realized to support animals during both normal feeding and emergency feeding (Sneath & Mclntosh, 2003, Naik *et al.*, 2011). Therefore, this study was performed to evaluate the different cereal species for better fodder yield, nutrient composition and cost of production under hydroponic fodder production technology.

MATERIALS AND METHODS

The experiment was carried out in a newly established polyhouse at National Pasture and Fodder Research Program, Khumaltar, Lalitpur, Nepal during July 2017 and July 2018.

Establishment of Poly house

A polyhouse was constructed in a 3.65 m length, 2.43 m width and 2.74 m height dimensions at National Pasture and Fodder Research Program, Khumaltar, NARC. The racks in three tiers were established inside to place the experimental trays. Antifungal tray of size of 0.75 m long and 0.37 m width were provisioned inside the polyhouse. The trays were used to spread germinated seeds of maize, oat and wheat for growing fodder with root mat. The automatic fogger was used for maintaining the relative humidity (90%) and for irrigation.

Experimental design and crop management

The experiment was executed in the Completely Randomized Design (CRD) with three treatments and 12 replications. The seed of maize, oat and wheat were used as thetreatments. A tray was used as an experimental unit.

Clean and unbroken seeds of maize were soaked in tap water for overnight and then kept in jute sack for two days. Germinated seeds were placed in antifungal trayskept in the racks of inside the polyhouse.

Field observations

Morphological characteristics of the plants from different cereals were recorded. Plant height and leaf colour data were recorded fromrandomly selected 5 plants within 20*20 cm quadrate used in tray. Growth parameters of the fodders were measured and recorded daily. The color patterns of the leaves were recorded by the visual observation of group of scientists with the use of 9-scale hedonic table.

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The plants were allowed to grow for 10 days until it reaches to the height of 20-30 cm and harvested on 11 days after sowing (DAS). Hydroponic fodder, a mat of germinated seeds, embedded in their white roots and green shoots was produced. The samples of green fodder were taken on the eleventh day in order to determine the dry matter and nutrient contents.Hydroponic fodder within 20 cm × 20 cm quadrate used in a tray were harvested with mat to calculate the fodder yield.

Laboratory analysis

Thesamples of hydroponic fodder were analyzed in the laboratory of the National Animal Nutrition Research Center, Khumaltar, Lalitpur, Nepal. The dry matter (DM) was estimated by using the continuous heating method. Crude protein fraction of the sample was analyzed by using AOAC protocol (AOAC, 1980) and fiber fractions were analyzed by using Georing and Van Soest protocol (Georing and Van Soest, 1970).

Economics of hydroponic maize fodder

The costs of production of hydroponic fodders from different cereals were calculated by using the Partial Budgeting Method. The cost of each expense was recorded and the cost of hydroponic fodder production was calculated.

Data analysis

All the collected data were processed and ANOVA was used to analyze the data. Mean comparison of the treatments was done by using Tukey's test. Statistical software GenStat discovery 18th Edition (VSNi, 2015) was used to analyze the data. The cost of production was calculated manually.

RESULTS AND DISCUSSION

Morphological characters of Hydroponic fodder of major cereals grains

The plant height varied significantly (P<0.001) for the hydroponic fodder from different cereal grains (Table 1). The mean plant height of hydroponic oat fodder (HOF) recorded as 27.11 cm was higher than that of hydroponic wheat fodder (HWF, 25.03 cm) and hydroponic maize fodder (HMF, 21.77 cm). Leaf colour was yellow green for all the cereals. The hydroponics fodder looks like a mat at the end of the germination period of about 8 days consisting of germinated seeds embedded in their white roots and green shoots (Snow *et al.*, 2008; Naik *et al.*, 2014).

Table 1. Morphological characters of hydroponic fodders from different cereal grains

Treatments	Plant height (cm)	Leaf color
Maize	21.77	Yellow Green
Oat	27.11	Yellow Green
Wheat	25.03	Yellow Green
SEM	0.75	
F-test	***	
LSD (0.05)	1.83	
CV%	4.3	

SEM: Standard error of mean, LSD: Least significant difference, CV: Coefficient of Variation, ****P*<0.001

Fodder yield

The year effect was obtained as non-significant (p>0.001) in the fodder yield of different cereal grains. In the combined analysis of both year data, the fodder yield varied significantly

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($P<0.05$) for hydroponic fodders of different cereal grains (Table 2). Oat produced better fodder yield compared to wheat and maize.

Several authors reported that the fresh yield and DM contents of the hydroponic fodder are mainly influenced by the type of crops, days of harvest, degree of drainage of free water prior to weighing, type and quality of seed, seed rate, seed treatment, water quality, pH, irrigation frequencies, light, growing period, temperature, humidity, clean and hygienic condition of the greenhouses (Trubey & Otros, 1969; Sneathand McIntosh, 2003; Dung *et al.*, 2010, Fazelietal, 2011). Accordingly, cereal species had also shown differences in fodder yield, fodder quality, and cost of production in the present experiment. From the perspective of higher fodder yield, oat seeds produced the highest hydroponic fodder. In the experiment, one kg of maize grain produced 5.32 kg of fresh fodder yield in the case of HMF which was lower than the report of Naik *et al.* 2015 (8-10 kg). Sneath and Mclntosh (2003) reported that oat grain gives 5.5 times fresh yield in 7 days and maize grains produce 3.5-6 times fresh yield in 7 days. In line with these reports, each kg of oat and maize seed yielded 7.96 and 5.32 kg of fresh fodders in 11 days in the experiment.

Table 2. Hydroponic fodderyield of different cereals grains at Khumaltar, Lalitpur, Nepal

Treatments	Yield (kg from per kg cereals grain)
Maize	5.32
Oat	7.96
Wheat	6.76
SEM	0.05
F-test	***
LSD (0.05)	0.13
CV%	1.2

SEM: Standard error of mean, LSD: Least significant difference, CV: Coefficient of Variation, ****P*<0.001

Nutrient composition of Hydroponic Fodder

The fodder DM content was higher for HWF and HOF in comparison to HMF (Table 3). HWF had shown better CP content than HOF and HMF, but contained lower fractions of Calcium (Ca) and was high in Acid Detergent Lignin (ADL). Modest CP and ADL content and better Ca contents were found in HOF. Better fiber fractions with lower NDF, ADF and ADL contents were found in HMF.

Table 3. Nutrient composition of hydroponic fodderfrom different cereals grains

Nutrient composition (%)	Maize		Oat		Wheat	
	Mean	SEM	Mean	SEM	Mean	SEM
Dry matter	12.55	2.05	14.13	0.71	14.49	1.18
Crude protein	12.51	0.83	13.96	2.08	16.16	1.59
Neutral detergent fiber	37.49	3.68	60.22	2.86	62.72	6.68
Acid detergent fiber	12.58	1.83	32.63	2.03	29.63	2.37
Acid detergent lignin	3.78	0.96	7.72	0.62	8.17	0.82
Calcium	2.41	0.22	2.88	0.74	2.19	0.40
Phosphorus	0.3	0.05	0.18	0.08	0.35	0.05

SEM: Standard error of mean

Several authors reported that the nutrient contents of hydroponics fodder are superior to certain common non-leguminous fodders, but comparable to leguminous fodder in terms of available organic matter, CP, ether extract and nitrogen-free extract content (Reddy *et al.*, 2014; Pandey & Pathak, 1991; Naik *et al.*, 2012). In the experiment, the CP content of the HMF was lower than the values reported by other authors (13.57% and 13.75% by *Naik et*

ISSN: 2661-6270 (Print), ISSN: 2661-6289 (Online)
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al., 2015; Adebiyi *et al.*, 2018, respectively). But, HOF and HWF had yielded better CP content than those reports. Although the HWF had better CP content, higher ADL content may retard its fodder quality. Moreover, Naik *et al.* (2015) reported that the increase in the content of CF, NDF and ADF; and decrease in the nitrogen-free extract and non-fibrous carbohydrate may be attributed to the increase in the number and size of cell walls for the synthesis of structural carbohydrates (cellulose and hemicellulose). The HOF produced a modest fodder yield with good quality in the experiment.

Per unit cost of production

The cost of production per kg of fodder was recorded the lowest (NPR 18.76) for HWF (Table 4). The production costof per kg HOF was highest (NPR 24.67). The cost expensed for a kg of HMF was NPR 20.67.

Per kg cost of production of all the fodders were higher in the experiment compared to other experiments conducted in India. The production cost of per kg of HMF found by Naik *et al.* (2013), Jemimah *et al.* (2015) and Gunasekaran *et al.* (2017) were NPR 5.60, NPR 3.00 and NPR 4.50, respectively. It was due to the lower cost of labor, seed, and electricity in those experiments. This denotes that the production costs of hydroponic fodders vary with the locations, market price, and accessibility. Gunasekaran *et al.* (2017) reported that even though hydroponic fodder is costlier, it can be effectively utilized for feeding animals during adverse situations such as drought, flooding, and cold wave at a reasonable cost.

Table 4. Per unit production cost of hydroponic fodders from different cereal crops

Input	HMF (NPR /kg)	HOF(NPR /kg)	HWF(NPR /kg)
Fixed Cost			
Tray	0.84	0.84	0.84
Operational Cost			
Seed	6.02	10.05	4.14
Electricity	0.25	0.25	0.25
Labor	13.53	13.53	13.53
Total cost	20.64	24.67	18.76

CONCLUSION

The productivity of hydroponic fodder was highest for oat whereas the fodder quality was modest. Wheat produced the best quality fodder with a modest fodder yield. The maize produces a lower fodder yield but with some good digestibility bearing quality parameters. The study revealed that oat is better for fodder yield with modest quality fodder and wheat is better for better quality fodder with modest yield.

ACKNOWLEDGEMENT

The authors are thankful to Nepal Agricultural Research Council (NARC), Singhadarbar, Plaza, Kathmandu, Nepal for providing financial support to conduct the study. Similarly, sincere thanks go to Mr. Bashanta Kumar Shrestha for the laboratory works and Ms. Sushila Pandit GC, Mr. Bishnu Mishra, and Ms. Sabitra Acharya for their assistance during the experiment.

Authors' Contributions

Ms. Sujaya Upreti: Experimentation, data processing and analysis and prepare manuscript
Dr. Ram Prasad Ghimire: Project and experiment design, guide to implementation, regular monitoring, providing necessary guidelines for research.
Dr. Niraj Banskota: Provide necessary support to conduct research and regular monitoring

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Conflicts of Interest

There is no any conflict to discloseamong the authors.

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