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Proliferation and nutritional profile of wheat and maize derived hydroponic fodder produced at small scale farmers' level

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Abstract

In Rwanda, livestock is a key sector playing an important role in the economic development of the country and community wellbeing. Livestock subsectors provide meat, milk, and eggs that are necessary to meet the nutritional requirements of a rapidly growing population. Despite its role in community development, the livestock subsector in Rwanda is still challenged by numerous factors, including but not limited to poor animal genetic potential, animal diseases, and poor nutrition in both quality and quantity. Hydroponic production is an ideal solution responding to the need for good-quality livestock fodder despite the high cost of establishing the required infrastructure. This study was conducted to assess the proliferation and nutritional profile of wheat and maize-derived hydroponic fodder produced at small-scale farmers' levels. By using locally available materials, small-scale hydroponic infrastrure were constructed, and two cereal grains were used as treatments: maize and beans in Randomised Complete Block Design (RCBD) with 6 replicates. Growth parameters like shoot length, leaf width, and root length data were collected daily from day 1 up to day 8, and 6 parameters of nutritional composition were tested in the laboratory. The results indicated that at 8th day shoot length, leaf width, and root length were 16.7, 12.3, and 1.7 cm, respectively, for maize and 17.8, 14.5, and 1.5 cm, respectively, for wheat shoot length, leaf width, and root length. For nutritional composition; the dry matter (DM) content was 19.30% for maize and 12.84% for wheat; protein and crude fibre were respectively 14.69% and 14.50% in wheat and 12.00% and 4.97 in maize, while other parameters, ash content, were 2.22% in maize and 2.12% in wheat; calcium residues were 0.08% in maize and 0.17 in wheat; and phosphorus were 0.10% in maize and 0.35 wheat. The study results revealed that locally available materials can be used to produce high-quality hydroponic fodder to be fed to livestock. To farmers, this study recommend the adoption of hydroponic production for the purpose of decreasing cost of production which is mostly associated with feeding.

***Key words**: Livestock, hydroponic, shoot, root, leaf*

Introduction

Livestock production plays an important role in economy and community welfare in developping contries by providing employment to producers and acting as a source of income necessary to cover family needs (Herrero et al., 2013; Smith et al., 2013). Beside it role in national and household economy, livestock provide meat, milk, egg and fish products that are sources of proteins, carbohydrates, lipids, minerals and vitamins required to provide a healthy food to human population (Lambrini et al., 2021; Balami et al., 2019; Wyness, 2016). In Rwanda, the Ministry of Agriculture and Animal Resources (MINAGRI) reported that the livestock sector produced 1,061,301 MT of milk; 197,778 MT of meat and 17,344 MT of eggs in 2022/2023 fiscal year (MINAGRI, 2023). Despite its role in livelihood and country econome, the livestock subsector in Rwanda is still challenged by numerous factors. Generally, the production system is mostly dominated by extensive production system which is essentially based on natural pasture where supplementary feeding of concentrates and cultivated pastures is uncommon in small ruminants (IFAD, 2019). The competion between livestock and human for cereals and other grains is another challenge for monogastric animal producers as it increases the cost of production due to increased demand of required inputs (IFAD, 2019; Steinfeld & Opio, 2010). To alleviate those challenges feeding hydroponic foodder might be an ideal solution for livestock producers.

Hydroponic involves utilization of water or enriched solution to sprout or grow plant in a controlled environment and without soil (Pastorelli et al., 2023). Hydroponic technology allow farmers to produce fodder for livestock on a small piece of land especially in densely populated areas or in areas where agriculture is difficult (Bekuma, 2019; Girma et al., 2018). Maize and barley are among cereal grains used to produce hydroponic fodder of 18.1 cm and 18.4 cm at the day five respectively (Murthy et al., 2017). The production per kg of grains used to produce hydroponic fodder stands at 4.82 kg for maize and 5.06 kg for barley (Murthy et al., 2017). At day eight, Gebremedhin et al., 2015 reported that the production from one kg of barley stands at 8 to 9 kg at the day 8. The nutritional analysis on the day 8 demonstrated that hydroponic fodder produced from barley contains 13.9% Crude

Proteins, 3.62% Ether Extract and 14.24% Crude Fiber on Dry Matter Basis (Gebremedhin *et al.*, 2015). Derspite its role in livestock industry, production of hydroponic fodder is still high and unaffordable by smallholder livestock farmers. Apart from the cost of establishment which is relatively high due to need of special equipment and infrastructure, hydroponic production for smallholder farmers is challenged by operational cost required to cover energy needed to maitntain temperature, humidity and lighting levels as per requirement (Vyshnavi *et al.*, 2023). The pesent study aims at characterizing the proliferation and nutritional profile of wheat and maize derived hydroponic fodder produced at small scale farmers' level using locally available materials.

Materials and methods

Study area

The present study was conducted in the Musanze District of Northern Province, Rwanda. Musanze is a densely populated district with a population density of 1,157 inhabitants/km2, with a population of 476,522 residents representing 23.4% of the total population of Northern Province according to NISR, 2023. As reported by NISR, 2023 , at least 66.3% of households are engaged in agriculture, in which 59.4% practice crop farming while 44.4% are engaged in livestock husbandry practices. Maize, sorghum, wheat, beans, soybean, cassava, sweet potato, irish potato, yams & taro, banana, vegetables, and fruits are commonest crops, respectively, cultivated by 46,263; 7,990; 3,759; 52,297; 327; 3,493; 20,351; 19,893; 1,422; 6,917; 8,584; and 39,924 households, from NISR, 2023. Livestock are raised by 25,952 households for cattle, 15,924 households for sheep, 12,765 households for pigs, 9,689 households for goats, 6,891 households for chickens, and 1,191 households for rabbits, according to NISR, 2023. The average monthly maximum temperature in Musanze District ranges from 20 to 24 oC, while the minimum temperature ranges from 11 to 13 oC, and there is an annual rainfall of 1,400 mm (LODA, 2021).

Establishment of hydroponic growing space

This study utilized a range of tools and equipment to construct a hydroponic house. This structure was assembled using trees, plastic sheets, and nails, with dimensions measuring 6 meters in length and 3 meters in width. Recycled plastic materials were repurposed to fabricate growing trays with small drainage holes to regulate water flow effectively and a size of 43cm x 30 cm for hydroponic fodder cultivation. Additionally, scrap lumber was repurposed to create a support platform with a gentle slope, facilitating the placement of the hydroponic growing trays. Inside the constructed house, a non slip concrete floor whith a slop was constructed to facilitate cleaning and drainage of used water.

Expermental design and Hydroponic cultivation

The experiment was set up in A Randomised Coplmete Block Design (RCBD) with 2 treatments, wheat and maize, and each treatment was replicated six times.Unbroked maize and wheat that are healthy, free from diseases and molds were selected for experiment. Selected seeds were washed using clean water and vinegar where 10 ml of vinegar were diluted within 20 litters of clean water to eliminate microbes and minimize the risk of mold growth in subsequent stages. During cleaning immature seeds floated to the surface were removed to ensure consistent growth.Cleaned seeds were soaked in plastic bucket which in turn were placed in dark room for 24 hours for maize and 12 hours for wheat. After soaking, the seeds were placed in a damp gunny bag to initiate germination and left to sprout for 24 hours for each. The sprouted seeds were then transferred into trays cleaned with water and vinegar at a rate of 1 kilograms of seeds per tray. On a daily basis, watering was done manually using cans at 5 hours interval to ensure that seeds are adequately kept moist. On a daily basis, shoot length, leaf width and leaf length were measured by using a ruler up to day 8 for 5 selected plant per tray.

Nutritional analysis

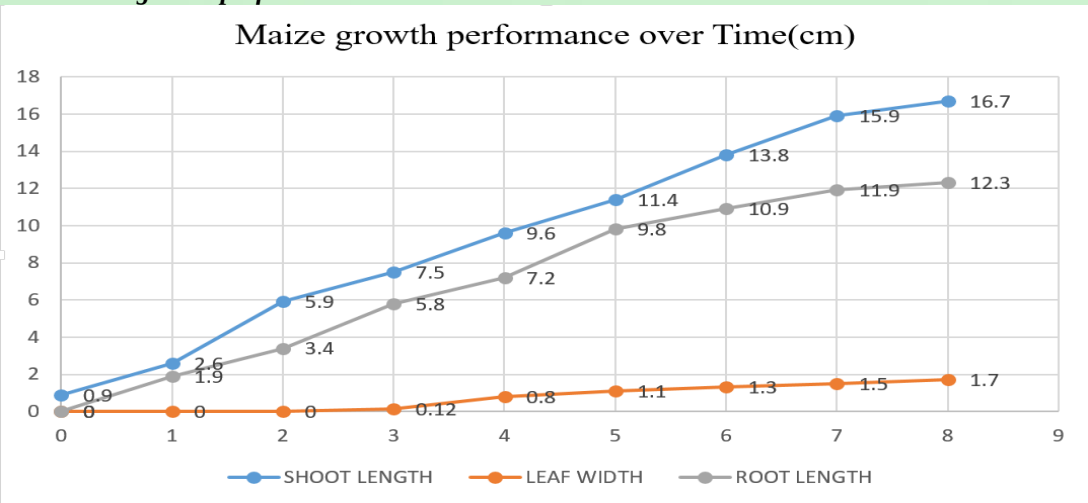
At day 8, obtained fodder were haversted and transported to the laboratory of Rwanda Agriculture and Animal Resources Development Board/Rubona Station for nutritional analysis on dry basis. Crude Protein content were determined using Kjeldahl method while Dry matter, Crude fiber, Ash content, Calcium and Phosphorus were respectively determined using dry oven method, calcination method, combustion method, titration method and carolimetric method

Data analysis

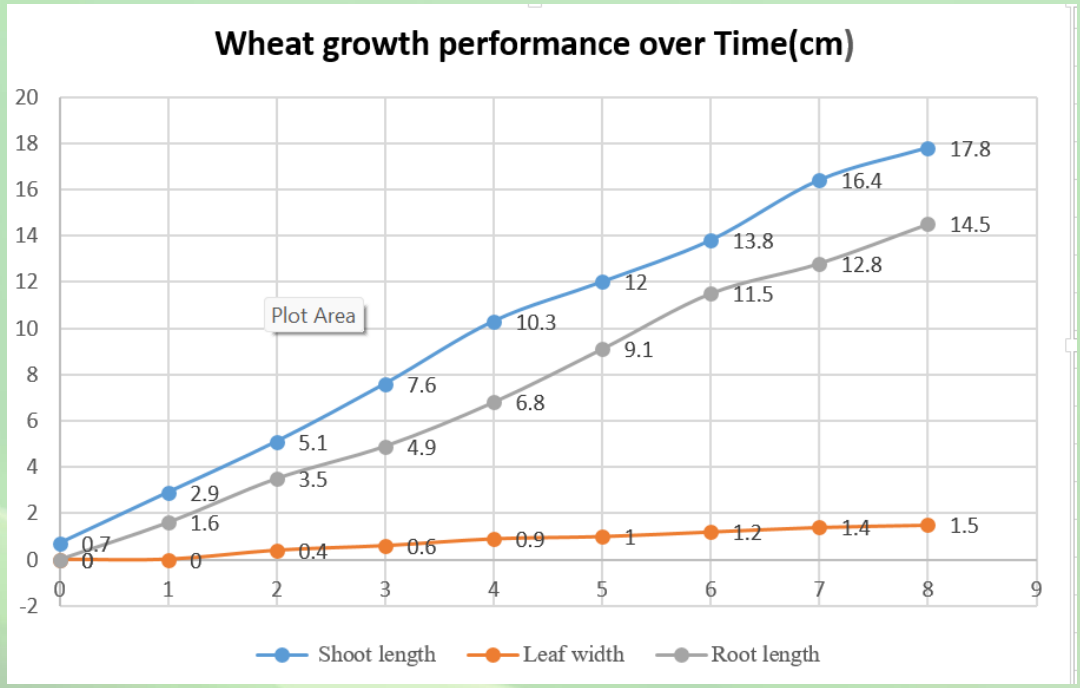
Collected data were recorded into Microsoft Excel, then imported into Statistical Package for Social Sciences Version 26 (SPSS, 26) for further analysis.

Results

Proliferation and growth performance



The present study demonstrated growth performance of maize plants in a hydroponic setting. In 8-day period a robust development was noticed across shoot length, leaf width, and root length of hydroponically cultivated maize plants (Figure 1). Beginning with a shoot length of 0.9 cm on day 0, the plants showed consistent and significant growth, reaching 16.7 cm by day 8. A noticeable development in leaf width was obsedrved from day 3 onwards, achieving 1.7 cm by day 8. Root length displayed a continuous growth from 0 cm at day 0 to 12.3 cm by day 8.



This study demonstrated that the growth performance of wheat hydroponic fodder over 8 day's period exhibit strong development across shoot length, leaf width, and root length. The shoot length initially was 0.7 cm on day 0 reached 17.8 cm by day 8. The leaf width of 0.4 cm was noticed on the day 2, achieving 1.5 cm by day 8. The root length showed a continuous progression from 0 cm on day 0 to 14.5 cm by day 8.

Nutritional composition of produced fodder

The present study determined the nutritional profile of hydroponically produced maize and wheat (Table 1). The dry matter content was 19.30% for maize and 12.84% for wheat. The higher proportion of protein nand crude fiber of respectively of 14.69% and 14.50% were observed in wheat. Other important nutrients observed were calcium observed at a rate of 0.08% for maize and 0.17% for wheat, and phosphorus observed at 0.10% for maize and 0.35% for wheat.

Grain	Parameters					
	Dry matter (%)	Crude protein (%)	Crude fiber (%)	Ash content (%)	Calcium (%)	Phosphorus (%)
Maize	19.30	12.00	4.97	2.22	0.08	0.10
wheat	12.84	14.69	14.50	2.12	0.17	0.35

Discussion

In the present study, normal water and affordable locally available materials were used to produce hydroponic fodder in a plastic sheet based infrastructure. Results of the study showed that the maize and wheat fodder with lush vegetation can be produced in 8 days from planting to harvest using hydroponic technique. A total of 6 and 7 kg of hydroponics was produced respectively on wheat and maize. Results from this study are not far from findings reported by Kide et al., 2015 in Dapoli where from one kg of Maize, the hydroponic fodder produced under green shed infrastructure and tap water was 6.75 kg at day 6, 7.47 kg at day 7 and 8 kg at day 8. The shoot length has grown from 2.6 cm at day 1 ; 9.6 cm at day 4 and 16.7 cm at day eight for maize. For wheat, shoot had a length of 5.1 cm at day 2; 10.3 cm at day 4 and 17.8 cm at day 8. The shoot length indicated by the findings of this study is slightly small when compared to the findings of the study conducted in Tamil by Jolad *et al.,* 2018 in which for maize, the shoot length was 3.17cm, 10.08 cm and 25.12 cm while were 2.21 cm, 6.93 cm and 18.40 cm observed in wheat respectively at day 2, day 4 and day 8. In Nepal, Upreti *et al.,* 2022 reported a plant height of 21.77 cm for maize and 25.03 cm for wheat at day 8. This disparity might be attributed to difference in growing conditions as reported by Khatri *et al.,* 2024 present study indicated that under hydroponic fodder cultivation, wheat grow well compared to maize.

Nutritional analysis revealed that hydroponic maize contains 19.30% Dry matter, 12.00% Crude Protein, 4.97% Crude Fiber, 0.08% Calcium and 0.10% Phosphorus. On the other hand, hydroponically produced wheat contains 12.84% Dry matter, 14.69% Crude Protein, 14.50% Crude Fiber, 0.17% Calcium and 0.35% Phosphorus. It is obvious that hydroponic fodder produced from wheat is nutritionally better than that from maize. This is in accordance with the study conducted by Upreti *et al.,* 2022 in which wheat produced good quality fodder compareed to that produced from maize.

Conclusion and recommendations

The present study revealed that locally available materials are useful in production of nutrient rich hydroponic fodder that are necessary to feed livestock. Wheat demonstrated an optimum result in terms of proliferation and growth with a highly nutritious products than maize. To smallholder farmers it is strongly recommended to adopt this affordable mode of producing green fodder at a limited piece of land. To future researchers, beside studying the effect of produced hydroponic fodder on growth and survival rate of different livestock, it is strongly recommended to also emphasize on microbiological contamination of produced hydroponic fodder.

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