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Effect of Feeding Hydroponic Fodders on the Performance of Dairy Cattle and Small Ruminants: - A Review

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Abstract
The main issue with livestock production is the lack of quality and quantity feed. Further, the non-availability of quality fodders around the year aggravates the constraints of. Further complicating the challenges of sustainable livestock farming is the year round high quality fodder. A force to adopt the environmentally friendly practices of producing fodder (hydroponic technology) is important to satisfy the demand of green fodder in the dairy industry. Plants are grown for brief (5-10 days) period without soil in hydroponic systems for the production of fodder. In many parts of the world, hydroponic fodder has a great promise for sustainable animal agriculture because of its effectiveness in addressing the global feed shortage. Hydroponic fodder is extremely competitive in the cattle farming industry due to its increased digestibility and palatability qualities. The advantages of feeding hydroponics fodder for livestock are increases milk yield and composition, dry matter intake, digestibility of nutrients, and it is important to improve the health status and daily body weight gain of calves, sheep, and goats.
Keywords: - body weight, health status, hydroponic fodder, milk yield
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Introduction

Climate changes and decreasing arable land make it difficult for producers to grow high-quality feedstuffs (Cross, 2015). The inclusion of grain is typical in ruminant diets; however, variability of grain prices affects how producers use these ingredients. Alternative feeding strategies dairy producers implement include decreasing grain supplementation and using by-products from the biofuel industry in cattle diets(Lawrence, 2019). The dairy animal should be frequently given high-quality green fodder for a sustainable dairy production. It is necessary to use a sustainable technique of cultivating fodder utilizing hydroponics in order to meet the need for green fodder from the dairy industry. The main obstacles to dairy farmers' ability to produce green fodder include the lack of suitable space for fodder cultivation due to small land holding sizes, longer growth times, and natural disasters. Additionally, the difficulty in finding high-quality fodder throughout the year makes it more difficult to practice sustainable dairy production(Naik et al., 2014). Hydroponically produced feed does not need soli and can be grown in less water, and it can be used as an alternative dairy cattle feed to beat the drought. High-quality oat and ryegrass hydroponic fodders can be produced through organic nutrient solutions ((Rivero et al., 2016). Hydroponics is one of the widely adopted technologies for fodder production in arid and semi-arid regions (Ebenezer et al., 2021). Hydroponic technique can be used for green fodder production of many forage crops in a hygienic environment free of chemicals like insecticides, herbicides, fungicides, and artificial growth promoters(Al-Karaki & Al-Momani, 2011). The outdoor-grown hydroponic fodder is highly palatable due to its tenderness, and younger harvesting age possesses lower indigestible fibres (including NDF and ADF) than conventional fodder. Highly nutritious hydroponic maize fodder is fed as alternative green fodder because of the improved CP content(Lim et al., 2022). Barley crop is considered the best choice that can be used for production of hydroponic green fodder with less water consumption; especially seeds of this crop are mostly available in the market at lower price than others which reduce the cost of hydroponic fodder production(Al-Karaki & Al-Hashimi, 2012). Fodder produced hydroponically is of a short growth period of 7–10 days and does not require high-quality arable land, but only a small piece of land for production to take place(Mooney, 2005). Milk and milk products are a source of food that provides nutritional energy, protein, minerals, and vitamins of high quality. Feed supplementation could be an excellent way to improve nutrient digestibility and absorption in dairy cattle, resulting in higher milk output and productivity by addressing the cow's nutritional needs through a feeding schedule. Using appropriate supplementation of different feeds improve the nutritive values of feeds, and the production, productivity, and quality of milk from dairy cattle.(Hassen et al., 2022). Formulated organic and organo-mineral nutrient solutions produced plants with similar yield and quality (Adeyemi et al., 2020). Cowpea (Vigna unguiculata; DU-3) could be sprouted hydroponically for 6 days and used as a feed supplement for dairy animals (Naik, et al., 2016). Hydroponic fodder is the transformation of seeds into quality, organic, palatable, disease-free lush green grass and root combination animal feed produced in a specially prepared hydroponic unit. Hydroponics fodders are good sources of chlorophyll, good sources of antioxidants and are highly nutritious which aid in developing a stronger immune system. Hydroponics fodder production requires less maintenance,

no fuel cost, no need for soil preparation, less manpower, and no damage from insects and other animals(Lende et al., 2021). Sprouting barley grain has some dry matter and digestible organic matter loss, and it does not recommend for animal feeding (Fazaeli et al., 2012). Green fodder feeding for dairy cattle has a sustainable and economical solution in dairy farming (Naik et al., 2015). Hydroponics fodder production requires less maintenance, no fuel cost, no need for soil preparation, less manpower, and no damage from insects and other animals (Lende et al., 2021). The different materials are needed to produce hydroponic fodder (fig 1).

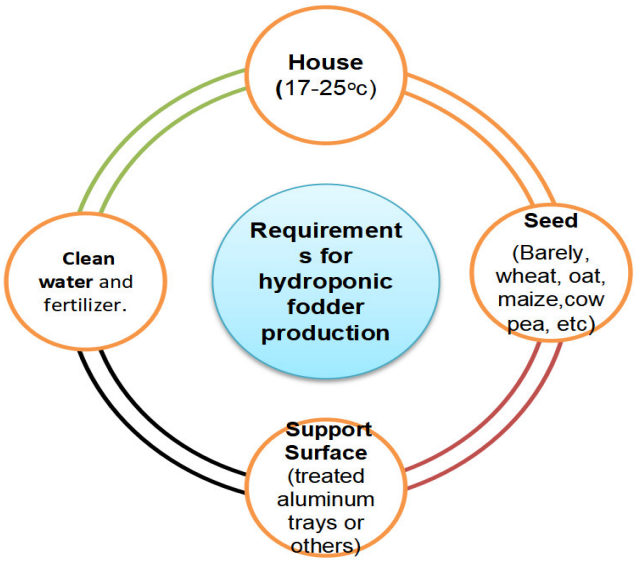


Figure (1) requirements for hydroponic fodder

Nutritional values of hydroponic fodder

Hydroponic green fodders have high feed quality, rich in proteins, fiber, vitamins, and minerals (Lorenz & D'Appolonia, 1980). Hydroponically produced barely, maize and vetch fodders have sufficient macro mineral contents (Abdula, 2022, Rani et al., 2019, Naik et al., 2014, Dhawaskar, et al., 2016, Gebremedhin, 2015). The literature based nutritional values of hydroponic fodder is presented in Table (1)

Table 1:- Nutritional values (%) of different hydroponic fodder

Crops	DM	Ash	CP	NDF	ADF	CF	Ca	P	References
Barely	130-280	30-60	110-180	310-510	140-350	130-170	3-7	4-6	(Fazaeli et al.,2011;Gebremedhin, 2015; Rajesh et al., 2018; Abdula,2022; Bulcha et al., 2022)
Wheat	90-150	40-60	180-340			30-180			(Al-Karaki & Al-Hashimi, 2012;Sánchez Del Castillo et al., 2013;Ali et al., 2019)
Maize	130-190	10-40	100-140			50-100	7-9	5-7	(Naik et al., 2014; Gebremedhin, 2015; Naik, et al., 2016; Naik et al., 2017; Rajkumar et al., 2018; Ali et al., 2019; Rani et al., 2019)
Sorghum	150-270	10-	120-190	230-500	70-200	150-200	-	-	(Al-Karaki & Al-Hashimi, 2012;Chrisdiana,2018; Garuma & Gurmessa, 2021)
Oat	-	40-60	120-230	400-520	280-400	-	-	-	(Sinchire et al., 2020)
Vetch	260-350	50-53	320-360	-	-	70-85	5	0.5	(Safa, 2019)
Cowpea	90-270	40-60	140-270	-	-	60-120	-	-	(Al-Karaki & Al-Hashimi, 2012;Naik, Dhawaskar, et al., 2016; Rajesh et al., 2018; Vennila, 2018)
Sesbania	95	34	373	-	-	72	-	-	(Ali et al., 2019)

DM=dry matter, CP=Crude protein, NDF=Neutral detergent fiber, ADF= Acid detergent fiber, ADL = acid detergent lignin and CF=crude fiber

Hydroponic fodder for dairy cow

Compared with dry roughages, green fodder is a natural, highly palatable, and digestible feed enriched with micronutrients resulting in improved nutrient digestibility, health, and performance of animals(Chethan et al., 2022). Feed intake, feed efficiency, live body weight, blood metabolites, milk yield, and milk composition of dairy cattle is not changed through the replacement of hydroponic barley fodder(20-60%) with corn silage(Kim et al., 2020 ,Fazaeli et al., 2021). Milk quality is improved through the hydroponic barely fodder inclusion (7.58%) in the total mixed ration (TMR) based feed (Agius et al., 2019). Cows fed sprouted barley fodder (1 .4 kg) in the TMR diet have lesser milk protein production but greater milk urea N (Soder et al., 2018). Replacing concentrate with hydroponic maize (6.1 kg/h/d) for dairy cows has a positive impact on boosting milk production, feed efficiency, and milk composition (Bari et al.,2020). The profit from the milk was only 6.79%, but the impact of hydroponics maize fodder supplementation (12%) on the health performances of cross-breed dairy cows is positive(Upreti et al., 2021).Hydroponic maize fodder supplementation (15 kg HMF/cow/day) for lactating cows can increase the digestibility of nutrients, milk production, and net profit (Naik et al., 2014). Hydroponics maize fodder can be replaced with the maize of the concentrate mixture partially with the fodder (50%) resulting in an improvement in the performance of the animals(Naik et al., 2017). Including hydroponics maize fodder (7% on a dry matter basis) in the corn silage-based diet of dairy cows results in increased dry matter intake, energy consumption, nitrogen conception, nutrient digestibility, and maintain persistence of milk production during late lactation of dairy cows (Nugroho et al., 2015). Hydroponically produced pigeon fodder (7.5 kg/cow/day) and raw and roasted pigeon pea grains (5 kg/cow/day/kind) are not changed the milk yield, weight gain, and milk chemical composition of dairy cows. Hydroponically produced pigeon pea fodder compared with grains as feed supplements is an economically sound alternative feeding management solution for farmers during the long dry season (Kamanga et al., 2018).

Hydroponic fodder for dairy calves

Inclusion of green fodder (22.8%, DM basis) in the feedlot of calves is not advantageous over barley grain, and the cost of the feed becomes high (Fazaeli et al., 2011). In contrast, feeding hydroponic barley fodder (2.5 to 5 kg/calves/day) for calves results in increased dry matter intake, nutrient digestibility, and improved growth rate of the Hariana male calves (Verma et al., 2015). Hydroponic maize fodder should be used for heifer feeding in situations where conventional feed is not available or cannot be grown due to adverse conditions (Naik et al., 2016). Hydroponics maize fodder has a beneficial effect on growth performance and digestible nutrients in Gir calves, and it can replace up to 75% of crude protein in concentrate mixture (Jediya et al., 2021). Calf starter replaced with hydroponic maize fodder (50-75% on a DM basis) has no adverse effect on the growth performance and nutrient digestibility of cross-bred calves(Rani et al., 2019). Similarly, feeding hydroponics maize fodder as a partial substitute for calf starter (7% on a protein basis) can improve dry matter intake, and daily body weight gain and lower the cost of production(Rajkumar et al., 2018).

Hydroponic fodder for small ruminants

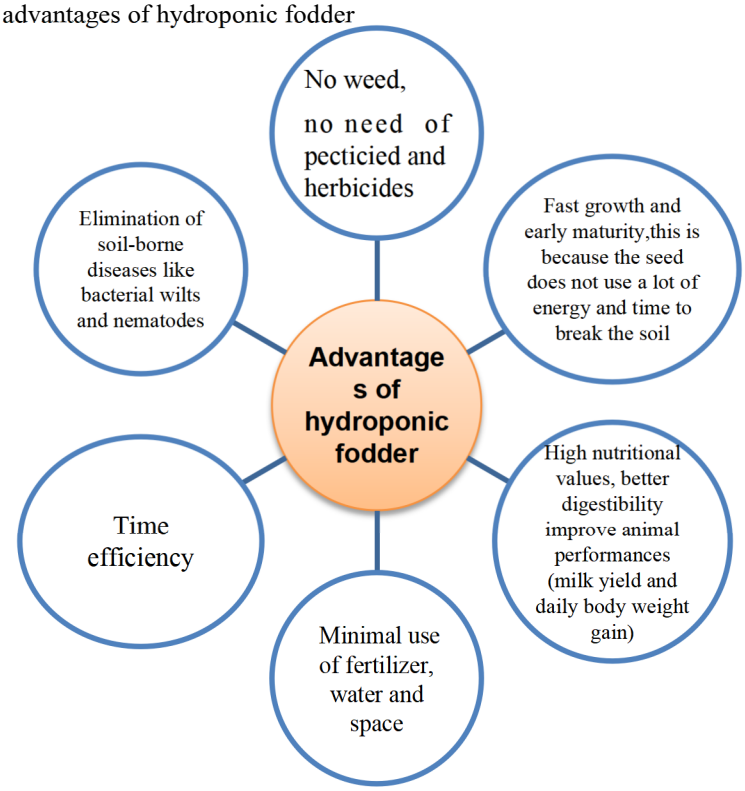
Feeding hydroponic maize and barley fodder (20-40%) for growing goats results in increased total dry matter intake, feed conversion efficiency, body weight gain, and economically valid (Gebremedhin, 2015). The nutrient digestibility, productive performance, and profitability of Tellicherry buck kids are improved through hydroponic maize fodder (25-50%) supplementation (Ebenezer et al., 2021; Jemimah et al., 2022). Using barley hydroponic fodder (37-100%) in replacement of barley grain in the diet of dairy Sannen goats is not cost-effective and profitable (Hayati et al., 2018). Barley sprout fodder (BSF) feeding at the different levels, 454 - 1362 g/day for Frisian ewes and 758-2270 g for Saanen does is not affecting milk yield. The fat, protein, and lactose components of the milk for sheep increased as the level of BSG increased, but lactose and total solids for Goat milk are not affected by BSF feeding. Cheese fatty acid composition for the two species is similar in BSF feed (Todd et al., 2022). Addition of hydroponic barley fodder (15-25%) in the diet of Awassi female lambs, conception rate and twin percentages are improved in ewes fed the forage, and it was no health problem observed in ewes (Eshtayeh, 2004). Similarly, hydroponic barley sprout supplementation for sheep has a positive effect on dry matter intake and animal performance(Farghaly et al., 2019). Sprouted barley at different levels (10-30%) of inclusion can improve the reproductive traits of Awassi male lambs (Al-Saadi, 2017). Sprouted barley (25-100%) with traditional feed improves the digestibility and fermentation characteristics of Awassi lambs(Al-Baadani et al., 2022). However, replacing wheat hay(50-100%) with hydroponic barley fodder did not influence feed intake, body weight changes, milk yield, and milk composition however, health conditions, mortalities, conception rates, and abortion are affected by the feed-in Awassi sheep (Badran et al., 2017)The use of hydroponically-grown wheat and barley fodder is a technically and economically viable option for Pelibuey sheep and Awasi lamb fattening (Sánchez Del Castillo et al., 2013,Ata, 2016). The increase in dry matter intake, nutrient digestibility, and nitrogen retention suggests that up to 21% of hydroponic barley fodder may be fed to Kermani sheep (Raeisi et al., 2018). Feeding barley sprouts (25-50%) for Barki ewes help to improve productive

performance (Helal, 2018). Hydroponically grown green wheat is a suitable substitute for a portion of the dietary dry-rolled corn grain and cottonseed meal in ewes diets during gestation and lactation without negative effects(Guerrero-Cervantes et al., 2016). The oat fodder (948g/lamb/day) replaced with commercial concentrate for Washera sheep indicated that daily body weight gain is improved (Mekonnen et al., 2019). Hydroponic barley fodder has not affecting feed intake, body weight changes, milk yield, and milk composition of lactating ewes; however, the fodder has positive effects on ewe's health conditions, mortalities, conception rates, and abortion. Hydroponic barley fodder is used as feed for lactating sheep as the cost of feed can be reduced by 42% (Abd Rahim et al., 2015). Feeding the mixture of conventional green fodder with hydroponic maize limits net nutrient availability and negatively affects the growth performance of lambs (Chethan et al., 2022) but hydroponic maize positively affects the growth performance of lambs(Lim et al., 2022).

Advantages of hydroponic fodder

In addition to the benefits such as shorter growth period and minimal water and land use, it also produce nutritious fodder that contains essential nutrients required for growth and reproduction of livestock(Ebenezer et al 2021). Figure (2) present the general advantages of hydroponic fodders for animal production.

Figure (2) general advantages of hydroponic fodder



Hydroponic fodder for mitigating GHG emissions

Livestock production is the major contributor to greenhouse gas (GHG) emissions. Increasing feed digestibility, intensive housing, improving health and welfare, increasing reproductive efficiency, and breeding for higher productivity are the main strategies that reduce GHG (Llonch et al., 2017).The inclusion of sprouted barley in the traditional diet can improve the nutritional value, digestibility, and fermentation characteristic of the feed(Al-Baadani et al., 2022). Barley hydroponic fodder is an important mechanism for minimizing GHG emissions and climate mitigation in livestock agriculture (Newell et al., 2021). An increased true dry matter digestibility of herbage- and haylage-based diets but did not affect fiber and crude protein digestibility, CH4 output, and bacterial efficiency were observed in the inclusion of hydroponic barley fodder (4.5 g) in the dairy cow diet (Hafla et al., 2014).

Conclusion

Feed shortage in terms of quality and quantity is the major problem of livestock production. Further, the non-availability of quality fodders around the year aggravates the constraints of sustainable livestock farming. The higher digestibility and palatability quality of hydroponic fodder makes it highly competitive for livestock farming. Supplementing hydroponics fodder for livestock feeding can increase milk yield and composition, dry matter intake, digestibility of nutrients, and improved health status and daily body weight gain of calves, sheep,

and goats.

Declarations

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Authors' contributions
Conceptualization, Investigation, and writing - original draft by GT and GM

Conflicts of Interest
The authors declare that they have no conflicts of interest.

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