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Contribution of Hydroponic Feed for Livestock Production and Productivity: A Review

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Abstract: Production of hydroponics fodder involves growing plants without soil but in water or nutrient-rich solutions in a greenhouse for a short duration (approx. 7 days). The use of nutrient solutions for the growth of hydroponic fodder is not essential, and only tap water can be used. The hydroponics fodder is more palatable, digestible, and nutritious while imparting other health benefits to the animals. Feeding hydroponically produced fodder increases the digestibility of the nutrients in the ration, which could increase milk production. In situations where conventional green fodder cannot be grown successfully, farmers can produce hydroponic fodder for feeding their dairy animals using low-cost devices. Nowadays, several countries are practicing it for their sustainable livestock production. Developing seed culture and new activities in hydroponics reduce production costs and help cooperatives produce and sell. Thus, it is vital to use hydroponic fodder for livestock, which is low cost and highly nutritive. Therefore, this technology is found to be conducive to almost all livestock. Hydroponic feed is a natural product produced without the use of any hormones, growth promoters, or chemical fertilizers. There is no pesticide, fungicide, dust, or toxic that could contaminate livestock products. This technology has a solution to avoid the scarcity of green feed in dry seasons and urban areas with a shortage of forage production. Therefore, there is a need to develop specific low-cost devices to produce hydroponics fodder under given local conditions. So further studies and development efforts should be made to expand its applications is needed.

Keywords: Hydroponic, Fodder, Livestock, Production, and Productivity.

Introduction

In Ethiopia, the livestock sub-contributions sector's contribution to national income and household livelihoods has been reported (Alemayehu and Getnet 2012). However, livestock output is low due to various issues, the most significant of which is insufficient nutrition (Young et al., 2013). Natural pastures, agricultural wastes, and aftermath grazing make up a substantial percentage of Ethiopia's animal feed resources (Gebremariam, T. and Belay, S., 2016). Because of their nutritional restrictions, these feed supplies cannot support higher animal productivity. Ethiopia has many indigenous fodder types of grass, forage legumes, and browse plants. Animal feed is primarily derived from these plant genetic resources (Mengistu et al., 2017). However, the indigenous forage gene pool can improve animal feed. Forage genetic resources have been minimal attention in the past to the collection, conservation, characterization, and evaluation of their forage genetic resources for sustainable use as forage (Adugna., 2008).

Ethiopia's livestock productivity is low. A large livestock population and less productive breeds, a lack of quality feed and seasonal variations in availability, poor livestock health and inadequate health services, inefficient livestock management, poor infrastructure, poor marketing and credit facilities, and insufficient knowledge of integrated mixed farming systems and capacity to exploit these resources are all factors that contribute to the livestock sector's poor performance (Yilma et al., 2011). Recent advances in livestock production in Ethiopia have primarily been attributed to herd expansion rather than productivity improvements. According to Gebremedhin (2007), fast rural population growth resulted in smaller farm sizes and less pastureland for animal production. Among the issues above, feed shortage is frequently a significant barrier and fundamental constraint to livestock output in crop-livestock mixed farming systems (Getnet, 2012).

The increase in livestock production demands nutrient requirement to feed animals, and the productive and reproductive performance of animals increase through feeding green fodder. Subsequently, feeding green fodder improve livestock products (Moorby et al. 2021). For example, providing hydroponic fodder to dairy animals helps the long-term economic development of the dairy industry, and it is a fact that a deficit occurs when dairy animals are fed without green fodder (Shah 2011; Masud et al., 2018). Livestock production in Ethiopia and other countries in the Arabian region is limited due to insufficient production and the high cost of imported green fodder.

Nevertheless, the main problems in producing green fodder emanate from reducing land size for fodder cultivation, labor requirements, shortages of water, and the elevated cost of fertilizers. Moreover, the lack of constant quality green fodder throughout the years magnifies the restrictions of sustainable dairy farming. Today, the scarcity of land has been shown as a significant constraint on forage production for ruminant animals like sheep, goats, and cattle. Ruminant animals, unlike monogastric mammals, are not constantly dependent on cereal grains. Alternative technologies, including hydroponics, were deemed necessary in light of these and other issues. The use of this technology as a livestock feed improves the performance of the animals (Girma and Gebremariam, 2018).

The cultivation of a broader range of land opens the door to animal forage production using hydroponics, and it is a cutting-edge agricultural technology that meets cattle nutrient needs (Munson, 2021). This method provides a guarantee of long-term fodder production at a reasonable cost. It is a method of cultivating crops such as Barley without pesticides or artificial growth agents. It is distinguished by a short growth period of 7–10 days and the requirement for a small plot of land for production. It contains high levels of protein, vitamins, fiber, and minerals, all of which are good for animals' health (Girma and Gebremariam, 2018). Therefore, this technology is an essential agricultural technique currently used in many countries (Tudor et al., 2011).

For more excellent forage grain germination in a short time, green hydroponic fodder requires specialized growth conditions in particular growing rooms. Wheat, oats, Barley, and other grains create fresh forages. Even if different fodder grains' development varies, the typical fresh forage mat reaches a height of 15 to 30 cm (Girma and Gebremariam, 2018). In the production of hydroponics, there is a recommendation to use water efficiently in semi-desert conditions (Al-Ajmi, 2009). Dairy cows could benefit from being fed high-quality green fodder, which could help to make dairy production more sustainable and profitable (Kumar, 2019). Small landholdings, unavailability of land for fodder cultivation, scarcity of water or saline water, non-availability of good quality fodder seeds, higher labor requirements, requirements of manure and fertilizer, more extended growth period (45-60 days), fencing to protect fodder crops from wild animals, natural calamities, and so on are some of the challenges faced by dairy farmers when producing green fodder (Naik et al., 2015).

Furthermore, the lack of consistent quality fodder throughout the year exacerbates the constraints of sustainable dairy farming. Hydroponics is presently emerging as an alternative technology for growing fodder for farm animals due to the previous limits and challenges encountered with the traditional method of fodder cultivation. The target of this paper was to review the available literature on the contribution of hydroponic feed for livestock production and productivity.

Contribution of Hydroponic Feed for Livestock Production and Productivity

Definition and Concept of Hydroponic Feeds

The definition of hydroponics comes from two Greek words, ' hydro' and 'ponics', which means water and working, respectively. This is the growing of a plant without soil. It's also known as sprouting grain or fodder. It requires only a little time to grow and mature in a controlled environment, such as a greenhouse. The term "greenhouse" refers to a growing habitat where environmental conditions are at least partially regulated (Shamshiri, 2018). However, the structure should be substantial enough for operational purposes (Chandra, 2003). Hydroponic forage is grown without soil but with the help of water. It is possible to employ nutrient-rich solutions for a limited time in a greenhouse. This fertilizer solution is not required, and tap water can be used instead. The fodder is a mat made up of roots, seeds, and plants with a height of around 20–30 cm. It is highly palatable, digestible, and nutritious for animals. There is an increment in milk production with the use of hydroponic fodder. This is the best alternative technology to use for dairy animals with low-cost materials in places where conventional green fodder production is limited (Prafulla et al., 2015).

History of Hydroponics Fodder Cultivation

Sneath and McIntosh supplied the background on hydroponics fodder production (2003). Sachs and Knop, working independently in England, perfected 'mariculture' techniques. European farmers cultivated cereal grasses to feed their cows in the winter during this time. On a broad scale, Gericke devised processes for growing plants in nutrient solutions. Leitch examined many tests with sprouted fodder for various livestock and poultry, concluding that sprouted fodder was the commercial exploitation of plant water culture processes to produce stock feed (Naik et al., 2015). After a while, Wood ward, an English scientist, attempted to grow plants in various water sources. In the middle 1990s, many units were designed and manufactured in many countries, including Europe and the USA, to produce hydroponics fodder. Harris, a scientist of South Africa, questioned the economics of the hydroponics system. Later, India made attempts to propagate hydroponics technology for forage production, and several workers undertook research works. Goat Dairy introduced hydroponic system technology in 2011 by creating some hydroponic system fodder production facilities under the Rashtriya Krishi Vikas Yojana of the Indian government at several dairy cooperative societies and doing research. Usually, the technique is not widely used in our country, but it is used in specific sections, such as Mekelle, Hydroponics Fodder Cultivations, and has significant importance on animal production and productivity, especially in dairy farming (Naik, 2011).

Method of Hydroponics Green Fodder Production

Land preparation concerns are less common on natural grasslands, which are the product of fire or earlier clearance than on forest areas (Simorangkir., 2007). Tree removal isn't always the best option. Removing trees to make ground machinery has resulted in later pasture management issues, weed invasion, and erosion. The piling of undesired timber and debris in gullies and water channels, which hurts their flow characteristics, is one of some land development schemes (Sengupta., 2021). Green fodder that has been properly maintained is one of the most cost-effective and high-value feeds available, providing significant benefits such as increased forage yields, lower feed costs, and better animal performance (Nigus., 2017). The choice of site is vital for production. Criteria to be selected good sites are there must be easy access, closely related species must not be grown within the same service cooperative, the area must be free of severe weeds, and the species must be well suited to that area (Sengupta., 2021). Figure 1 expresses how to prepare Hydroponics Green Fodder Production for cattle feeds during the shortage of feeds.

Figure 1 Method of Hydroponics Green Fodder Production

Principles of Hydroponic Fodder Production

Hydroponics grows cereal grains with necessary moisture, nutrients, and the absence of a solid growing medium. The sprouted shoot and root mat are harvested and fed to animals. Germination responds to the supplied moisture and nutrient and produces 200 to 300mm long forage green shoots with interwoven roots within 7 to 10 days. Different cereal grains can be used for fodder production with varied chemical and structural changes throughout the growing processes. Enzyme activation is necessary for the hydrolysis of nutrients to their simpler forms. Grain variety, quality, treatments like nutrient supply, pH, water quality, soaking time, etc., are influencing factors for the amount of sprouted and quality fodder (Girma and Gebremariam, 2018). It is the science of growing plants in nutrient-rich solutions instead of soil. It can be efficiently used to pressure the land to grow green feed for the livestock. Plants require three things to flourish, water, nutrients, and sunlight. Hydroponics is a straightforward way of providing all these nutrients without soil under controlled environmental conditions to optimize the growth of plants.

Technology has been tested on various crops such as Maize, Sorghum, Barley, and Oats to produce high-quality, nutritious green fodder for dairy animals (Swain and Sahoo, 2020). Besides this, hydroponics can be used to grow wheatgrass, paddy saplings, etc., in seven days for optimum growth. Fodder obtained from hydroponics consists of grass with grains, roots, stems, and leaves compared to only stem and leaves part in conventionally grown fodder (Sneath and Mclntosh, 2011). The following figure 2. Shows maize hydroponic prepared and harvested for dairy cattle milk productions.

Figure 2 Hydroponic Innovative Technology for Dairy Business

Importance of Hydroponic Feeds

Hydroponics avoids problems shown in conventional methods of fodder production. This is realized through the use of mall pieces of land with a vertical growing process that permits the production of a large volume of hydroponic fodder on a fraction of the area needed by conventional fodder production and thus increases the stocking capacity of livestock. Different reviews indicated that around 600kg of maize fodder per day is produced in 50 square meters of area (Kumar, 2019). However, for the production of the same amount of fodder 1ha of land is required in the conventional production method. Water required for hydroponic fodder production is less due to water recycling activities.

Therefore, 1kg of maize hydroponic fodder is produced in 7 days with 1.5 liters (if water is reused) or 3 liters (if water is not reused). The water which is not reused can be utilized for the garden near the production unit. Only one person suffices to produce around 600kg of hydroponic fodder. Moreover, fodder can be produced without soil preparation, constant weed removal, fencing, and post-harvest loss per daily requirement (Bekuma., 2019). As per demand, green fodder round the year: technology can provide green fodder round the year.

Constant supply can be organized Irrespective of rain, storm, sunshine, or drought (Barrow, 2016). Increasing the nutritive value of fodder through hydroponics makes it possible to enhance the nutritive value by adding additional growth promoters, nutrients, etc., to have quality milk from the dairy animals. Natural feed for animals: growing green fodder through hydroponics is entirely by natural source. Enhancement of milk production: Providing green fodder to milk animals can compensate the concentrate feed for having an economically viable milk-producing industry (Zhang, 2018). Minimizing loss of fodder: Green fodder produced from hydroponics will be fully utilized as there won't 'be loss of the fodder during feeding compared to wastages of chopped traditional grasses during consumption the animal (Naik, Singh, 2013).

One of the characteristics of hydroponic fodder is its high growth with no completion for nutrients and higher yield. No crop rotation is needed since there is no soil nutrient loss (Resh., 2012). In here, weeds are minimal as the media is sterile and closed. The hydroponic fodder is with high moisture content and is dust-free. The operational systems like irrigation, cooling, and lighting are controlled and maintained at a low cost. This produces quality succulent green feed throughout the year (Al-Kodmany., 2018). This feed is highly palatable, nutritious, and free from contamination than commercial feed. This leads to the low requirement of concentrate feeds. Therefore, this technology is found conducive for almost all livestock. Hydroponic feed is a natural product produced without hormone, growth promoter, or chemical fertilizer. There is no pesticide or fungicide, dust, or any toxic contaminating livestock products (Joseph, 2005).

The Yield of Hydroponics Fodder

The crops' fresh yield and D.M. content are essential for successful hydroponics fodder production. During sprouting of the seeds, there is an increase in the fresh weight and a consequent decrease in the D.M. content, which is mainly attributed to the imbibitions of water (leaching) and enzymatic activities (oxidation) that depletes the food reserves of the seed endosperm without any adequate replenishment from photo-synthesis by the young plant during the short growing cycle (Sneath and Mclntosh, 2011; Mbarki et al., 2020) The type of crops mainly influences the fresh yield and D.M. content of the hydroponics fodder, days of harvesting, degree of drainage of free water before weighing, type and quality of seed, seed rate, seed treatment, water quality, pH, irrigation frequencies, the nutrient solution used, light, growing period, temperature, humidity, clean and hygienic condition of the greenhouse, etc. (Molla and Birhan, 2010). The use of nutrient solution lowers the D.M. loss, which may be due to the absorption of minerals, thus increasing the ash content and the final weight of the hydroponics fodder (Dung et al ., 2010).

Hydroponic Fodder Nutritional Value

Hydroponic fodder from cereal grains deviates in its nutrient content. When starch content decreases, both organic matter and dry matter content decrease. Sprouting catabolizes starch into the plant's soluble sugar biochemical purpose (Halo et al., 2020). However, ether extract of hydroponic fodder increases due to the increment of structural lipids and chlorophyll as the plant grows. The development of structural carbohydrates increases crude fiber, neutral detergent fiber, and acid detergent fibers but decreases nitrogen-free extract. In terms of crude protein, organic matter, ether extract, and nitrogen-free extract, aquatic feed is superior to ordinary non-leguminous feed (Girma and Gebremariam, 2018). However, the gross energy, metabolizable energy, and total digestible nutrient content decrease during sprouting. This is due to energy up taken during respiration of the plant (Fazaeli et al., 2011). There are changes in the nutrient content of the cereal grains and hydroponics. The D.M. content is decreased due to the decrease in the starch content. Starch is catabolized to soluble sugars during sprouting to support the growing plants' metabolism and energy requirement for respiration and cell wall synthesis, so any decrease in the amount of starch causes a corresponding decrease in D.M. The increase in C.P. content may be attributed to the loss in D.M., particularly carbohydrates, through respiration during germination, and thus, longer sprouting time is responsible for more significant losses in D.M. and an increase in protein content (Brown et al., 2018).

Besides, the absorption of nitrates facilitates the metabolism of nitrogenous compounds and thus increases the C.P. levels. The use of nutrient solution enhances the C.P. content of the hydroponics fodder higher than the tap water, which may be due to the uptake of nitrogenous compounds. The ash content of the sprouts increases more if the nutrient solution is used rather than water which may be due to the absorption of minerals by the roots (Dung et al., 2010). The nutrient contents of hydroponics fodder are superior to certain common non-leguminous fodders but comparable to leguminous fodders. (Naik et al., 2012). Conventional fodders are less nutritious than hydroponic fodders. Nutrient deviation occurs during sprouting, increasing crude protein, ether extract, and nitrogen-free extract but decreasing crude fiber, total ash, and insoluble ash. On planet earth, the most enzyme-rich plants are hydroponic fodder sprouts. (Panchal., 2020; Finckh., 2019). The sprouts' enzyme active are at the highest level from germination to seven days. They are rich in anti-oxidants, especially in the form of β-carotene. In terms of palatability, hydroponic fodder performs outshine. There is no nutrient wastage as the shoots and roots of the plant are consumed together. Improvement indigestibility of feed is evident with supplementation of hydroponic fodder in dairy cows (Prafulla et al., 2015).

Hydroponics Fodder Feeding Value

Hydroponics fodder is tasty, and the germinated seeds implanted in the root system are absorbed alongside the plant's shoots, resulting in no nutrient waste. Animals will sometimes eat the green sections of the hydroponics fodder but not the roots, which can be avoided by combining the hydroponics fodder with the other roughage components of the diet (Naik, 2014; Vennila, C., 2018). However, there have been instances of the animals ' D.M.' consumption decreasing. Hydroponics fodder boosted the digestion of the ration's nutrients, related to the fodder's tenderness (Naik, 2014). The hydroponics fodder's nutrient digestibility was comparable to highly digestible legumes such as other clovers. The milk yield significantly increases when hydroponics fodder is fed, maybe because of enhanced nutritional digestibility (Naik, 2014; Helal., 2018).

The hydroponics fodder's nutrient digestibility was comparable to highly digestible legumes such as other clovers. The milk yield significantly increases when hydroponics fodder is fed, maybe because of the enhanced nutritional digestibility (Naik, 2014). The cost of hydroponics fodder is mainly controlled by the cost of seed, which accounts for roughly 90% of the overall cost of production (Naik et al., 2012). The cost of hydroponics feed is relatively reasonable in low-cost systems when the seed is cultivated on the farmers' land. Farmers' comments demonstrated increased milk production, improved overall fertility, conception rates, coat or fleece appearance, and general animal health, among other things (Anonymous, 2012).

Digestibility/Degradability

Even if there is a loss in the dry matter content of sprouted barley fodder, their digestibility has an advantage. In the rumen, the digestibility of the sprouts is higher than the cracked grain. However, comparing the digestibility of shoot and root sprouts, shoots quickly degrade in the rumen. Therefore, ruminant animals prefer leafy than steamy (Gebremedhin, 2007; Dung, 2010).

Energy

Hydroponic sprouts and processed grains are both nutritious and digestible feeds. Sprouting of grains changes the starch to sugar. On dry matter bases, the energy value of sprouts are less than grains with gross energy loss (Sneath and Mclntosh, 2011; Farghaly et al., 2019).

Protein

Animal performance is highly dependent on the critical element, protein, and thus there is a need to analyze the feed value of the fodder. In sprouts, crude protein, ash, and other minerals except potassium are concentrated on a dry matter base than barley grains (Eastwood, 2013). The increase in dry crude protein content is due to dry matter content loss, mainly carbohydrates. Moreover, nutrient absorption also facilitates the metabolism of nitrogenous compounds, increasing the crude protein content. Nutrient solutions improve the crude protein level of the hydroponic fodder than using tap water (Dung et al., 2010; Naik et al., 2017).

Vitamins

Hydroponic fodder is especially rich in vitamin C, and E. Sprouting improves the grain's vitamin content (Shit, 2019). However, the increase in individual vitamins is too tiny that its practical use in addressing the nutritional requirements of cereal-based diets makes little difference on the feed value (Sneath R, Mclntosh F, 2011).

Minerals

In hydroponic fodder, root growth helps for mineral uptake, which changes the ash and protein contents swiftly from day four onwards. Absorption also facilitates the metabolism of nitrogenous compounds and thus increases the crude protein level (Girma and Gebremariam, 2018). The type of irrigated water for the hydroponic fodder changes the mineral content. However, chelating sprouting makes minerals more available (Naik et al., 2012).

Significance of Hydroponic Feed/fodder for Livestock Productivity

Milk yield and productivity

Studies on the improvement of milk production through hydroponic fodder feeding show improvement than animals fed cereal grains, hay, or silage. Hydroponic fodder increase milk yield by 10.07% in dairy cows(Salo, S., 2019). Canadian dairy farmers also indicate the increase in feed intake of their cows after feeding hydroponic fodder and improve their milk yield by 3.6kg per day over the lactation period. Moreover, farmers from South Africa reported a drop of 3.6 liters of milk after a leave off of 6.8 kg fed per day (Shit, 2019; Mooney, 2005).

Increase Productivity of Meat

Hydroponic fodder improves the Bodyweight fain of lambs, and this is realized due to having high bioactive enzymes and ingredients that improve livestock performances. Moreover, increased body weight also reflects microbial activity in rumen and enhanced nutrient digestibility (Shit, 2019). In beef cattle, average increase in Bodyweight is achieved through feeding hydroponic fodder than maize—similarly, birds and other animals (Tudor et al. 2011; Ata, 2016).

Nutritional Factor versus Hydroponic Feed

Phytic acid is found in the seed coat and germ of plant seeds. The principal impact of phytic acid is that it causes inefficient absorption in the blood by generating insoluble compounds with minerals such as calcium and iron. Phytic acid levels are reduced when seeds are sprouted (Girma and Gebremariam., 2018; Xia et al., 2020). Enzymes also remove other potentially harmful chemicals during germination. In the digestion of protein, fat, and carbohydrates, the digestive enzymes in sprouts act as biological catalysts. Sprouts have a hundred times more enzymes than fruits; therefore, enzyme activity determines the physiological action of vitamins, minerals, and trace elements (Almuhayawi et al., 2021). The period of highest enzyme activity of the sprouts is said to be between germination and seven days. Because of the inhibitors, enzymes are still active when cereal grains are not germinated. Seed degradation is prevented for years using these inhibitors (Naik et al., 2012).

Conclusions and Recommendations

Hydroponics is an agro-technology that may be made using low-cost materials that offer animals more nutritious, tasty, and digestible fodder. Hydroponics is an ingenious alternative solution to address land scarcity and climate change. Several countries are now using it to ensure the long-term viability of their cattle industries. Seed culture and innovative hydroponic activities reduce production costs and make it easier for cooperatives to manufacture and market their products. As a result, using low-cost, high-nutritive hydroponic feed for cattle is crucial. This strategy can help eliminate green feed shortages, especially during dry seasons and in urban regions where forage production acreage is limited. This approach is preferred over cereal grains and other concentrated meals because of its high intake, pleasant, and digestible features. Progressive modern farmers can apply this technology to their dairy cattle to boost productivity. In circumstances where it has been cultivated.

Therefore need to develop specific low-cost devices to produce hydroponics fodder under given local conditions. Need to conduct long-term feeding trials for different types of hydroponics fodder on different livestock categories about their productive and reproductive performance. Development of feeding strategies concerning hydroponics fodder under different agro-climatic conditions and also, since the technique is not widely introduced in our country, further research and development endeavors should be carried out for its further utilization.

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