Science Frontiers
2022; 3(1): 1-7
http://www.sciencepublishinggroup.com/j/sf
doi: 10.11648/j.sf.20220301.11

Contribution of Hydroponic Feed for Livestock Production and Productivity

Abdi Hassen Abdula[1, 2]

[1]Animal Productions, Meta Agricultural Office, Harar, Ethiopia

[2]Africa Center of Excellence for Climate Smart Agriculture and Biodiversity Conservation, Department of Climate Smart Agriculture, Haramaya University, Haramaya, Ethiopia

Email address:
abd51042@gmail.com

To cite this article:
Abdi Hassen Abdula. Contribution of Hydroponic Feed for Livestock Production and Productivity. *Science Frontiers.* Vol. 3, No. 1, 2022, pp. 1-7. doi: 10.11648/j.sf.20220301.11

Received: December 6, 2021; **Accepted**: December 31, 2021; **Published**: January 12, 2022

Abstract: Production of hydroponics feed involves the growing of 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 the hydroponic feed is not essential and only tap water can be used. The hydroponics feed is more palatable, digestible, and nutritious while imparting other health benefits to the animals. Feeding of hydroponically produced feed increases the digestibility of the nutrients in the ration, this could contribute to an increase in milk production and productivity of dairy cow. In situations where conventional green feed cannot be grown successfully, hydroponic feed can be produced by farmers 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 very vital to use hydroponic feed 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 that is produced without the use of any hormones, growth promoters, or chemical fertilizers. There is no pesticide or fungicide, dust or toxic that could contaminate the products of livestock. This technology has a solution to avoid the scarcity of green feed in dry seasons and urban areas having a shortage of land for forage production. Therefore, there is a need to develop specific cheapest material for the production of hydroponics feed under given local conditions. So further studies and development efforts should be made to expand its applications is needed.

Keywords: Hydroponic, Feed, Livestock, Production and Productivity

1. Introduction

In Ethiopia, the livestock sector's contribution to national income, 40% of GDP of agricultural economy and household livelihood [1]. However, livestock productions output is low due to a variety of issues, the most significant of which is insufficient nutrition and quality feeds [2]. Natural pastures, agricultural wastes, and aftermath grazing make up a substantial percentage of Ethiopia's animal feed resources [3]. Because of their nutritional restrictions; these feed supplies are unable to support higher animal productivity. Ethiopia has a large variety of indigenous feed grasses, forage legumes, and browse plants. Animal feed is primarily derived from these plant genetic resources [4]. Although the indigenous forage gene pool has the potential to improve animal feed. Forage genetic resources have been very limited attention in the past to the collection, conservation, characterization, and evaluation of their forage genetic resources for sustainable use as forage [5].

Ethiopia's livestock productivity is low due to their feeding system and feed productions. 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 [6]. Recent advances in livestock production in Ethiopia have primarily been attributed to herd expansion rather than productivity improvements. According to Gebremedhin [7],

fast rural population growth resulted in smaller farm sizes and less pastureland for animal production. Among the aforementioned issues, feed shortage is frequently regarded as a major barrier and fundamental constraint to livestock output in crop-livestock mixed farming systems [8].

The increase in livestock production demands nutrient requirements to feed animals. Productive and reproductive performance of animals increases through feeding green feed. Subsequently, feeding green feed improves livestock products [9]. For example, providing hydroponic feed to dairy animals helps to long-term economic development of the dairy industry, and it is a fact that deficit occurs when dairy animals are fed without green feed [10, 11]. Livestock production in Ethiopia and other countries in the Arabian region is limited due to insufficient production and the high cost of imported green feed. Nevertheless, the main problems in producing green feed emanate from reducing land size for feed cultivation, labor requirements, and shortages of water and the elevated cost of fertilizers. Moreover, the lack of constant quality green feed throughout the years magnifies the restrictions of sustainable dairy farming. Today, the scarcity of land has been shown as a great 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 [12].

The cultivation of a wider range of land opens the door to animal forage production using hydroponics and it is a cutting-edge agricultural technology that meets the nutrient needs of cattle [13]. This method provides a guarantee of long-term feed production at a reasonable cost. It is a method of cultivating crops such as barley without the use of 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 [12]. Therefore, this technology is an important agricultural technique currently used in many countries [14].

For greater forage grain germination in a short length of time, hydroponic green feed requires specialized growth conditions in particular growing rooms. Wheat, oats, barley, and other grains are used to create fresh forages. Even if the development of different feed grains varies, the typical fresh forage mat reaches a height of 15 to 30 cm [12]. In the production of hydroponics, there is a recommendation to use water efficiently in semi-desert conditions [15]. Dairy cows could benefit from being fed high-quality green feed, which could help to make dairy production more sustainable and profitable [16]. Small land holdings, unavailability of land for feed cultivation, scarcity of water or saline water, non-availability of good quality feed seeds, higher labor requirements, requirements of manure and fertilizer, longer growth period (45-60 days), fencing to protect feed crops from wild animals, natural calamities, and so on are some of the challenges faced by dairy farmers when producing green feed [17]. Furthermore, the lack of consistent quality feed throughout the year exacerbates the constraints of sustainable dairy farming. Hydroponics is presently emerging as an alternative technology for growing feed for farm animals due to the foregoing limits and challenges encountered with the traditional method of feed cultivation. The target of this paper was to review the available literatures on the contribution of hydroponic feed for livestock production and productivity.

2. Literature Review

2.1. 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 feed. 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 in which the environmental conditions are at least partially regulated [18]. However, the structure should be substantial enough for operational purposes [19]. 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 feed 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 feed. This is the best alternative technology to use for dairy animals with low-cost materials in places where conventional green feed production is limited [20].

2.2. History of Hydroponics Feed Cultivation

Sneath and McIntosh supplied the background on hydroponics feed production in 2003. Sachs and Knop, working independently in England, perfected the techniques of 'Nariculture.' 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 the nutrient solution. Leitch examined several tests with sprouted feed for various livestock and poultry, concluding that sprouted feed was the commercial exploitation of plant water culture processes to produce stock feed [17]. After a while, Wood ward, an English scientist, attempted to grow plants in various sources of water. In the middle 1990s, a range of units was designed and manufactured in many countries including Europe and USA to produce hydroponics feed. Harris, a scientist, of South Africa questioned the economics of the hydroponics system. Later, attempts were made in India for propagating hydroponics technology for forage production, and research works were undertaken by several workers. Goat Dairy introduced hydroponic system technology in 2011 by creating several hydroponic system

feed production facilities under the Rashtriya Krishi Vikas Yojana of the Indian government at several dairy cooperative societies and doing research. Normally, the technique is not widely used in our country, but it is used in specific sections of the country, such as Mekelle Hydroponics Feed Cultivations, and has a significant impact on animal production and productivity, especially in dairy farming [21].

2.3. Method of Hydroponics Green Feed Production

Land preparation concerns are less common on natural grasslands, which are the product of fire or earlier clearance than on forest areas [22]. Tree removal isn't always the best option. The removal of trees to make way for 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 harms their flow characteristics, is one of the worst elements of some land development schemes [23]. Green feed that has been properly maintained is one of the most cost-effective and high-value feeds available, providing major benefits such as increased forage yields, lower feed costs, and better animal performance [24]. 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 serious weeds and the species must be well suited to that area [23]. This figure 1 express how to prepared Hydroponics Green Feed Production for cattle feeds during the shortage of livestock feeds.

Figure 1. *Method of Hydroponics Green Feed Production.*

2.4. Principles of Hydroponic Feed Production

Hydroponics is the growing of cereal grains with necessary moisture, nutrient, and the absence of a solid growing medium. The sprouted shoot and root mat are harvested and fed to animals. Germination is a response to the supplied moisture and nutrient and produces 200 to 300mm long forage green shoot with interwoven roots within 7 to 10 days. Different cereal grains can be used for feed production with varied chemical and structural changes throughout the growing processes. Enzyme activation is found 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 feed [12]. It is a science of growing plants in nutrients rich solutions instead of soil and can be efficiently used to take pressure off 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 the need for the soil under controlled environmental conditions to optimize the growth of plants. Technology has been tested on various crops like Maize, Sorghum, Barley, and Oats for producing high-quality nutritious green feed for dairy animals [25]. Besides this hydroponics can be used for growing wheat grass, paddy saplings, etc in seven days of time for optimum growth. Feed obtained from hydroponics consists of grass with grains, roots, stem, and leaves as compared to only stem and leaves part in conventionally grown feed [26]. The following figure shows maize hydroponic prepared and harvested for dairy cattle milk productions.

Figure 2. *Hydroponic Innovative Technology for Dairy Business.*

2.5. Importance of Hydroponic Feeds

Hydroponics avoids problems shown in conventional methods of feed 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 feed on a fraction of the area needed by conventional feed production and thus increases the stocking capacity of livestock. Different reviews indicated that around 600kg maize feed per day is produced in 50 square meters of the area [16]. However, for a production of the same amount of feed 1ha of land is required in the conventional method of production. Water required for hydroponic feed production is less due to water recycling activities. Therefore, 1kg of maize hydroponic feed 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. For the production of around 600kg of hydroponic feed, only one person suffices. Moreover, a feed can be produced without soil preparation, constant weed removal, fencing, and post-harvest loss and per daily requirement [27]. Green feed round the year: technology is

capable to make provision for the green feed round the year, as per demand Constant supply can be organized Irrespective of rain, storm, sunshine, or drought [28]. Increasing of nutritive value of feed through hydroponics it is 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 of green feed through Hydroponics is completely by natural source. Enhancement of milk production: providing green feed to milk animals can compensate for the concentrate feed so as to have an economically viable milk-producing industry [29]. Minimizing loss of feed: Green feed produced from hydroponics will be fully utilized as there won't 'be loss of the feed during feeding as compared to wastages of chopped traditional grasses during consumption by the animal [30].

One of the characteristics of hydroponic feed is its high growth with no completion for nutrients and higher yield. Since there is no soil nutrient loss, no crop rotation is needed [31]. In here, weeds are minimal as the media is sterile and closed. The hydroponic feed is with high moisture content and is dust-free. The operational systems like irrigation, cooling, and lighting systems are controlled and maintained at a low cost. This produces quality succulent green feed throughout the year [32]. This feed is highly palatable, nutritious, and free from contamination than commercial feed. This leads to a low requirement for concentrate feeds. Therefore, this technology is found conducive for almost all livestock. Hydroponic feed is a natural product that is produced without the use of any hormone, growth promoter, or chemical fertilizer. There is no also pesticide or fungicide, dust, and any toxic that could contaminate the products of livestock [33].

2.6. Hydroponics Feed Yield and Its Dry Matter Contents

For successful hydroponics feed production, fresh yield and DM content of the crops are important. During sprouting of the seeds, there is an increase in the fresh weight and a consequent decrease in the DM 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 short growing cycle [26, 34]. The fresh yield and DM content of the hydroponics feed are mainly influenced by the type of crops, days of harvesting, degree of drainage of free water prior to 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 [35]. The use of nutrient solution lowers the DM loss which may be due to the absorption of minerals thus increasing the ash content and the final weight of the hydroponics feed [36].

2.7. Hydroponic Feed Nutritional Value

Hydroponic feed from cereal grains deviates in its nutrient content. When starch content decreases, both organic matter, and dry matter content decrease. Sprouting catabolizes starch into soluble sugar biochemical purposes of the plant [37]. However, ether extract of hydroponic feed increases due to the increment of structural lipids and chlorophyll as the plant grows. The development of structural carbohydrates increase, crude fiber, neutral detergent fiber, and acid detergent fibers but decreases nitrogen-free extract. Hydroponic feed show superiorities from common non-leguminous feeds in terms of crude protein, organic matter, and ether extract, and nitrogen-free extracts [12]. However, during sprouting the gross energy, metabolizable energy, and total digestible nutrient content decreases. This is due to energy up taken during respiration of the plant [38]. There are changes in the nutrient content of the cereal grains and hydroponics The DM content is decreased which may be due to the decrease in the starch content. During sprouting, starch is catabolized to soluble sugars for supporting the metabolism and energy requirement of the growing plants for respiration and cell wall synthesis, so any decrease in the amount of starch causes a corresponding decrease in DM. The increase in CP content may be attributed to the loss in Dry matter (DM), particularly carbohydrates, through respiration during germination and thus longer sprouting time is responsible for greater losses in DM and an increase in protein content [39]. Besides, the absorption of nitrates facilitates the metabolism of nitrogenous compounds and thus increases the CP levels. The use of nutrient solution enhances the CP content of the hydroponics feed 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 [36]. The nutrient contents of hydroponics feed are superior to certain common non-leguminous feeds but comparable to leguminous feeds [40].

Conventional feeds are less nutritious than hydroponic feeds. Nutrient deviation occurs during sprouting which increases in crude protein, ether extract, nitrogen-free extract but decreases in crude fiber, total ash, and insoluble ash. On planet earth, the most enzyme-rich plants are hydroponic feed sprouts [41, 42]. Enzyme active of the sprouts are at the highest level from germination to seven days age. They are rich in anti-oxidants especially in the form of β-carotene. In terms of palatability, hydroponic feed 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 feed in dairy cows [20].

2.8. Hydroponics Fodder Feeding Value and Its Digestibility

Hydroponics feed 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 feed but not the roots, which can be avoided by combining the hydroponics feed with the other roughage components of the diet [43, 44]. However, there have been instances of the

animals' DM consumption decreasing. Hydroponics feed boosted the digestion of the ration's nutrients, which could be related to the feed's tenderness [43]. The hydroponics feed's nutrient digestibility was comparable to that of highly digestible legumes such as other clovers. The milk yield is significantly increased when hydroponics feed is fed, maybe because of the enhanced nutritional digestibility [43, 45].

The cost of hydroponics feed is mostly controlled by the cost of seed, which accounts for roughly 90% of the overall cost of production and relatively reasonable in low-cost systems when seed is cultivated on the farmers' land [40]. Farmers' comments demonstrated increased milk production, improved overall fertility, conception rates, coat or fleece appearance, and general animal health, among other things [46]. Even if there is a loss in dry matter content of sprouted barley feed there is being an advantage in their digestibility. In the rumen, the digestibility of the sprouts is higher than the cracked grain. However, comparing the digestibility of shoot and root sprouts shoots easily degrade in the rumen. Therefore, ruminant animals prefer leafy than steamy [16, 36].

2.8.1. 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 is less than grains with gross energy loss [26, 47].

2.8.2. Protein

Animal performance is highly dependent on the critical element which is protein. Thus there is a need to analyze the feed value of the feed. In sprouts, crude protein, ash, and all other minerals except potassium are highly concentrated on dry matter bases than barley grains [48]. The increase in dry crude protein content is due to lose in dry matter content particularly carbohydrates. Moreover, nutrient absorption also facilitates the metabolism of nitrogenous compounds which leads to an increase in the crude protein content. Nutrient solutions improve the crude protein level of the hydroponic feed than using tap water [36, 49].

2.8.3. Vitamins

Hydroponic feed is especially rich in vitamin C and E. Sprouting improves the vitamin content of the grain [50]. However, the increase in individual vitamins is too small that its practical use in addressing the nutritional requirement of cereal-based diets makes little difference on the feed value [26].

2.8.4. Minerals

In hydroponic feed, root growth helps for mineral uptake which in turn 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 [12]. The type of irrigated water for the hydroponic feed changes the mineral content. However, the process of chelating sprouting makes minerals more available [40].

2.9. Significance of Hydroponic Fodder/Feed for Livestock Productivity

2.9.1. Milk Yield and Productivity

Studies on the improvement of milk production through hydroponic feed feeding show improvement over animals fed cereal grains, hay, or silage. Hydroponic feed increase milk yield by 10.07% in dairy cows [51]. Canadian dairy farmers also indicate the increase in feed intake of their cows after feeding hydroponic feed 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 [50, 52]. Therefore, hydroponic feed technology expansion's can increase milk production and dairy productivity especially area where seasonal drought extended.

2.9.2. Increase Productivity of Meat

Hydroponic feed improves the bodyweight fain of lambs. This is realized due to having high bioactive enzymes and ingredients that improve livestock performances. Moreover, the increase in body weight also reflects microbial activity in rumen and enhanced nutrient digestibility [50]. In beef cattle average increase in Body, weight is achieved through feeding the hydroponic feed than maize. Similarly, improvement is reported in birds and other animals [14, 53].

2.10. 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 [12, 54]. 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 [55]. 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 with the use of these inhibitors [40].

3. Conclusions and Recommendations

Hydroponics is an agro-technology that may be made using low-cost materials that offer animals more nutritious, tasty, and digestible feed. Hydroponics is an ingenious alternative solution to address land scarcity and climate change. It is now being used by several countries 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. Because of its high intake, pleasant, and digestible features, this approach is preferred over cereal grains and other concentrated meals. 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 for the production of hydroponics feed under given local conditions. Need to conduct long-term feeding trials for different types of hydroponics feed on different categories of livestock with regard to their productive and reproductive performance. Development of feeding strategies with respect to hydroponics feed 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 utilizations.

References

[1] Aleme, A., and Lemma, Z., (2015). Contribution of Livestock Sector in Ethiopian Economy: A Review. *Advances in Life Science and Technology* 29: pp 79-91. doi: www.iiste.org.

[2] Young, J. R., Rast, L., Suon, S., Bush, R. D., Henry, L. A. and Windsor, P. A., (2013). The impact of best practice health and husbandry interventions on smallholder cattle productivity in southern Cambodia. *Animal Production Science*, *54* (5), pp. 629-637.

[3] Gebremariam, T. and Belay, S., (2016). Livestock feed resources utilization practices in Tanqua-Abergelle district of Tigray, Northern Ethiopia. *Tropical animal health and production*, *48* (6), pp. 1183-1190.

[4] Mengistu, A., Kebede, G., Feyissa, F. and Assefa, G., (2017). Review on major feed resources in Ethiopia: Conditions, challenges and opportunities. *Academic Research Journal of Agricultural Science and Research*, *5* (3), pp. 176-185.

[5] Adugna, T., (2008). Livestock feed resources assessment, constraints and improvement strategies in Ethiopia. Middle-East Journal of Scientific Research, 21 (4), pp. 616-622.

[6] Yilma, Z., Guernebleich, E., Sebsibe, A. and Fombad, R., (2011). A review of the Ethiopian dairy sector. *Addis Ababa, Ethiopia: FAO Sub Regional Office for Eastern Africa (FAO/SFE)*.

[7] Gebremedhin B (2007) Forage seed inputs supply in Ethiopia. ILRI, Addis Ababa, Ethiopia.

[8] Getnet A (2012). The evaluation of forage seed production in Ethiopia. In: Getnet Assefa, Mesfin Dejene, Jean Hanson, Getachew Anemut, Solomon Mengistu and Alemayehu Mengistu (eds), Forage Seed research and development in Ethiopia. Ethiopia institute of agricultural research, Addis Ababa, Ethiopia. Pp 15-32.

[9] Moorby, J. M. and Fraser, M. D., (2021). New feeds and new feeding systems in intensive and semi-intensive forage-fed ruminant livestock systems. *Animal*, p. 100297.

[10] Shah VD, Makwana M, Sharma S. (2011). Economics of production, processing and marketing of feed crops In Gujarat. India Research Study No. 144.

[11] Masud, M. T. and Bhowmik, S., (2018). Feasibility Study of Solar-Powered Hydroponic Feed Machine in Bangladesh. In Renewable Energy in Developing Countries (pp. 85-94). Springer, Cham.

[12] Girma, F. and Gebremariam, B., (2018). Review on hydroponic feed value to livestock production. *Journal of Scientific and Innovative Research*, *7* (4), pp. 106-109.

[13] Munson, R., (2021). *Tech to Table: 25 Innovators Reimagining Food*. Island Press.

[14] Tudor G, Darcy T, Smith P, Shallcross F, (2011). The intake and live weight change of drought master steers fed Hydroponically grown, young sprouted barley feed, Department of Agriculture Western Australia Agriculture and Veterinary Science, 2: 24-30.

[15] Al-Ajmi A, Salih A, Kadhim I, Othman Y (2009). Yield and water use efficiency of barley feed produced under hydroponic system in GCC countries using tertiary treated sewage effluents. Journal of Phytol. 1: 342-348. 15.

[16] Kumar, R., (2019). Year Round Green Feed Production and Conservation for Sustainable Dairy Farming in India. *Sustainable Agriculture*, p. 38.

[17] Naik PK, Swain BK, Singh NP (2015), Hydroponics: its feasibility as an alternative to cultivated forages. In: Proc. 9th Biennial Animal Nutrition Association Conference on 'Eco-responsive Feeding and Nutrition: Linking Livestock and Livelihood' held at Guwahati, India, January, pp. 74-87.

[18] Shamshiri, R. R., Jones, J. W., Thorp, K. R., Ahmad, D., Che Man, H. and Taheri, S., (2018). Review of optimum temperature, humidity, and vapour pressure deficit for microclimate evaluation and control in greenhouse cultivation of tomato: a review. *International agrophysics*, *32* (2).

[19] Chandra P, Gupta MJ. (2003). Cultivation in hi-tech greenhouses for enhanced productivity of natural resources to achieve the objective of precision farming. Precision Farming in Horticulture; 64-74.

[20] Prafulla KN, Bijaya K, Swain NP, Singh. (2015). Production and Utilization of Hydroponics Feed Indian. Journal of Animal Nutrition, 32 (1): 1-9.

[21] Naik, P. K., Dhuri, R. B. and Singh, N. P. (2011). Technology for production and feeding of hydroponics greenfeed. Extension Folder No. 45/ 2011, ICAR Research Complex for Goa, Goa.

[22] Simorangkir, D., (2007). Fire use: Is it really the cheaper land preparation method for large-scale plantations?. *Mitigation and adaptation strategies for global change*, *12* (1), pp. 147-164.

[23] Sengupta, M., (2021). *Environmental impacts of mining: Monitoring, restoration and control*. CRC Press.

[24] Nigus, A., (2017). Pasture management and improvement strategies in Ethiopia. *Journal of Biology, Agriculture and Healthcare*, *7* (1), pp. 69-78.

[25] Swain, B. B. and Sahoo, P. K., (2020). Low-cost grain sprout production using hydroponics.

[26] Sneath R, Mclntosh F, 2011). Review of hydroponic feed production for beef cattle. Queens land Government, Department of Primary Industries, Dalby, Queensland.

[27] Bekuma, A., (2019). Nutritional Benefit and Economic Value of Hydroponics Feed Production Technology in Sustainable Livestock Production Against Climate Change-A Mini-Review. *Advances in Applied Sciences*, *4* (1), p. 23.

[28] Barrow, C. J., (2016). *Water resources and agricultural development in the tropics*. Routledge.

[29] Zhang, C., Campana, P. E., Yang, J., Yu, C. and Yan, J., (2018). Economic assessment of photovoltaic water pumping integration with dairy milk production. *Energy Conversion and Management*, *177*, pp. 750-764.

[30] Naik PK, Singh NP (2013). Hydroponics feed production: an alternative technology for sustainable livestock Production against impeding climate change. In: compendium of Model Training Course 'Management Strategies for Sustainable Livestock Production against Impending Climate Change', held during November 18-25.

[31] Resh, H. M., (2012). Hydroponic food production: a definitive guidebook for the advanced home gardener and the commercial hydroponic grower. CRC press.

[32] Al-Kodmany, K., (2018). The vertical farm: A review of developments and implications for the vertical city. *Buildings*, *8* (2), p. 24.

[33] Joseph M. (2005). Growing Cattle Feed hydroponically scholarship report.

[34] Mbarki, S., Skalicky, M., Vachova, P., Hajihashemi, S., Jouini, L., Zivcak, M., Tlustos, P., Brestic, M., Hejnak, V. and Zoghlami Khelil, A., (2020). Comparing salt tolerance at seedling and germination stages in local populations of Medicago ciliaris L. to Medicago intertexta L. and Medicago scutellata L. *Plants*, *9* (4), p. 526.

[35] Molla, A. and Birhan, D. (2010). Competition and resourceutilization in mixed cropping of barley and Durum wheat under different moisture stress levels. World J. Agric. Sci. 6 (6): 713-719.

[36] Dung DD, Godwin IR, Nolan JV. (2010) Nutrient content and *in sacco* digestibility of barley grain and sprouted Barley. *Journal of Animal, Veterinary Advances*; 9 (19): 2485-2492.

[37] Halo, B. A., Al-Yahyai, R. A. and Al-Sadi, A. M., (2020). An endophytic Talaromyces omanensis enhances reproductive, physiological and anatomical characteristics of drought-stressed tomato. *Journal of plant physiology*, *249*, p. 153163.

[38] Fazaeli H, Gol-mohammadi HA, Shoayee AA, Montajebi N, Mosharraf SH. (2011). Performance of feedlot Calves fed hydroponics feed barley. Journal of Agricural Science and Technology.

[39] Brown, D., Ng'ambi, J. W., Osinowo, O. A., Adeola, A. T. and Adebiyi, O. A., (2018). Effects of feeding hydroponics maize feed on performance and nutrient digestibility of weaned pigs.

[40] Naik PK, Dhuri RB, Swain BK, Singh NP (2012). Nutrient changes with the growth of hydroponics feed Maize. Indian Journal of Animal Nutrition.

[41] Panchal, B., (2020). Regulation of Flowering in Vegetable Crops Under Protected Cultivation. *AGRICULTURE & FOOD E-NEWSLETTER*.

[42] Finckh, M., (2019), September. SESSION 12. BREEDING FOR INTRASPECIFIC DIVERSITY. In *First European Conference on Crop Diversification* (p. 179).

[43] Naik PK (2014). Hydroponics green feed for dairy animals. Recent Advances in Animal Nutrition, Azadpur, Delhi-110033, India.

[44] Vennila, C., (2018). Productivity, nutritive value, growth rate, biomass yield and economics of different hydroponic green feeds for livestock.

[45] Helal, H. G., (2018). Productive and reproductive performance of Barki ewes fed on sprouted barley grains on desert by-products during lactating period. *Res. J. Anim. Vet. Sci*, *10*, pp. 37-48.

[46] Anonymous. (2012). Moo-ve aside, hydroponics technologies. The Gomantak Times. Oct. 11, 2012.

[47] Farghaly, M. M., Abdullah, M. A., Youssef, I. M., Abdel-Rahim, I. R. and Abouelezz, K., (2019). Effect of feeding hydroponic barley sprouts to sheep on feed intake, nutrient digestibility, nitrogen retention, rumen fermentation and ruminal enzymes activity. *Livestock Science*, *228*, pp. 31-37.

[48] Eastwood, M. A., (2013). *Principles of human nutrition*. Springer.

[49] Naik, P. D., Fatarpekar, B., Swain, D., Chakurkar, B. and EB Singh, N. P., (2017). Nutrient changes during sprouting of hydroponics Alsando (Vigna unguiculata).

[50] Shit, N., (2019). Hydroponic Feed Production: An Alternative Technology for Sustainable Livestock Production In India. *Explor Anim Med Res*, *9* (2), pp. 108-119.

[51] Salo, S., (2019). Effect of Hydroponic Feed Feeding on Milk Yield and Compostion of Dairy Cow. *Journal of Natural Sciences Research*, *9* (8), pp. 1-2.

[52] Mooney J. (2005). Growing cattle feed hydroponically. Meat and livestock Australia. p. 30.

[53] Ata, M., (2016). Effect of hydroponic barley feed on Awassi lambs performance. *Journal of Biology, Agriculture and Healthcare*, *6* (8), pp. 60-64.

[54] Xia, Q., Tao, H., Li, Y., Pan, D., Cao, J., Liu, L., Zhou, X. and Barba, F. J., (2020). Characterizing physicochemical, nutritional and quality attributes of wholegrain Oryza sativa L. subjected to high intensity ultrasound-stimulated pre-germination. *Food Control*, *108*, p. 106827.

[55] Almuhayawi, M. S., Hassan, A. H., Al Jaouni, S. K., Alkhalifah, D. H. M., Hozzein, W. N., Selim, S., AbdElgawad, H. and Khamis, G., (2021). Influence of elevated CO_2 on nutritive value and health-promoting prospective of three genotypes of Alfalfa sprouts (Medicago Sativa). *Food Chemistry*, *340*, p. 128147.