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Role of Hydroponics Technology in Green Fodder Production as Livestock Feed Resource: Review

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Abstract: The aim of this study is to review, document and disseminate information to have better understanding of hydroponic green fodder production and utilization as livestock feed. Production of green fodder in sufficient quantities to meet the current demand has occurred as a crucial problem today. One of the methods to overcome this problem is hydroponic cultivation of green fodder as animal feed. Hydroponics green fodder production encompasses the growing of plants without soil but with little water or nutrient-rich solution in a greenhouse using high-cost hi-tech or low-cost devices for a short duration. Different fodder crops can be used for this system based on the environmental conditions, cost and availability of seeds. Green fodder produced by the hydroponic system is highly palatable, digestible, nutritious, safe, healthy and environmentally friendly and can be fed suitable for all types and categories of animals. It has a meaningful advantage in water use efficiency, reducing space and time, constant supplying of quality fodder, increasing fodder yield, reducing forage loss, less labor required and economic feasibility against conventional/traditional methods

INTRODUCTION

Accessibilityof excellent green fodder and its production to meet the current demand has always been a challenge to livestock farmers. Less availability of land, more labor for farming (sowing, weeding, harvesting, etc.), more time for harvesting, non-availability of constant quality forage, a requirement of fertilizer (organic or inorganic); the uncertainty of rainfall, water shortage and climate change are the major limitations for green fodder production encountered by the livestock farmers and so livestock productivity. Due to the above constraints the hydroponics technology is coming up as an alternative to grow fodder for farm animals, that would restore fodder and livestock production[1]. Hence, one can take advantage of hydroponic, a technology that has transformed green fodder production in the 21st century (https://www.livestocking.net).

Hydroponic green fodder has been used for thousands of years, dating back to the hanging gardens of the Babylon era and when European dairy farmers fed sprouted grains to their cows during winter to maintain milk production and improve fertility. There is renewed interest in this technology due to the shortage of green

fodder in most of the Middle East, African and Asian countries and nowadays it is the latest technology for growing green fodder without soil in an ecological environment. Many livestock farmers are influenced by this method and are switched to hydroponic fodder production from conventional production methods, as the fodder produced by this method is highly nutritious, through this process someone can produce fodder year-round conserve water. Hydroponically grown fodder is considereda sprouted forage, which provides a variety of highly nutritive food with important mineral and vitamin contents to livestock and birds[2].

DISCUSSION

Definition of hydroponic technology: In definition, the word hydroponics has been gotten from the Greek word 'water working'. Hydro and ponics signify 'water and 'working', respectively and it is an innovation of developing plants in water or nutrient-rich solution but without using any soil[3]. Fodder crops produced by hydroponics technology are also known as hydroponics fodder, sprouted fodder or sprouted grain or alfaculture and fresh fodder biscuits. Sprouting of the grains is made inside a greenhouse within a short period of approximately seven days and also can be produced and fed insituations where feed under cultivation cannot be successfully grown.

The 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[4,5,6]. It is a well-known technique for high fodder yield, year-round production and least water consumption[7,6].

Types of hydroponic fodder production systems: Hydroponic green fodder can be produced both in large, sophisticated, automated commercial systems with environmental control, or in low-cost systems, where the ambient environment is suitable for fodder production and the choice depends on the farmers' financial capabilities[8].

High-cost hi-tech hydroponic systems: These are highly cultured, fully computerized fodder production systems with controlled environments and are immune to natural weather variations. The required water, light, temperature, humidity and aeration are fully controlled by sensors. The provision for recycling of water is also available[8,9].

Low-cost hydroponic systems: In developing countries, the expensive, automated commercial hydroponic fodder production systems are being replaced by low-cost hydroponic systems made up of locally available materials. The low-cost greenhouses or shade net structures can be prepared from bamboo, wood, MS steel, or galvanized iron steel. The cost of such systems depends upon the type of construction materials used. It is any type of shelter, garage, basement, room or low-density plastic sheets, greenhouse or poly-hut with a solid floor of compacted earth, concrete, cobblestone, etc., where the temperature, humidity and light can be controlled are used for hydroponic fodder production.

Suitable fodder crops for hydroponic fodder production technology: Green livestock feed can be grown hydroponically much the same as vegetables, flowers and other plants. Hydroponic fodder systems are usually used to sprout cereal grains, such as barley, oats, wheat, sorghum and corn, or legumes, such as alfalfa, clover, or cowpeas. Barley is the most commonly grown fodder because it usually gives the best yield of nutrients[10]. Fodder maize, grain maize, grain cowpea and horse gram is the best-performing crops under hydroponics for getting higher green fodder yield and nutritive value with relatively lesser cost. Forage mixtures are another option. Dependent on the ecological and agro-climatic conditions and availability of seeds, hydroponics technology can be used for green fodder production for various varieties of fodder crops. The used for hydroponics production must be clean, undamaged, viable or good quality, safe for animal health or free from chemicals and insect infestation that is available for producing the best quality fodder.

Feeding of hydroponic fodder to livestock: Hydroponics green fodder is palatable and the germinated seeds embedded in the root system are also consumed along with the shoots of the plants without any nutrient wasting[11]. Along with seed, stem, leaf and root, it is highly edible and rich in protein (10-17%). Sprouting changes, the nutritive characteristics of the grain. Enzymes break down storage components into more simple and digestible fractions; for example, starch to sugars, proteins to amino acids and lipids to free fatty acids. There is an increase in fiber and some vitamins and a decrease in phytic acid, an anti-nutritional factor[12].

Supplementation of 5-10 kg hydroponic fodders per cow per day increases milk production by 8-13% and meat quality based on the digestibility of the nutrients[13]. Hydroponic fodder increases milk yield by 10.07[14], 12.5, 13.73[15] and 8-13%[16] due to feeding of hydroponic fodders to lactating cows and also increases milk fat percentage and pH with superior quality of milk[17,18].

Reduced fat coat, reduced death rate, improved performance and reduced feed expenses in piglets fed hydroponic fodder[19,20]. When geese were fed optimal dosage of hydroponic green herbage which constituted 25-30% of the total diet weight increased, poultry population survival rate by 2.0%, egg production rate by 3.8% and the hatching egg yield by 4.9%[21]. The

carotenoid content in egg yolk ranged from 1.62-3.50 µg. The content of Vitamins A and B_2 was higher by 3.19 and 2.32 µg, respectively, compared to that in the control. The production profitability level increased by 9.6%. Eight percent improvement in body weight gain in birds and other animals[29]. These fodders are suitable for use for all types and categories of animals: cows, sheep, goats, pigs, horses, rabbits, fish and birds[22]. However, full feeding of sprouts is usually inappropriate due to the high moisture content of the feed, the high cost of the feed and the scale which would be needed to produce sufficient dry matter. During feeding livestock with hydroponic green fodder, the following points should be considered:

- Hydroponic fodder should be used as feed supplement. The following are the recommended amounts of fodder that can be fed daily to a single animal depending of body weight using the rule that an animal can eat up to 1-1.5% of its weight of hydroponic fodder daily:
  - Cattle live weight 300-400 kg, approximately 3-5 kg day^{-1}
  - Shoats live weight 25-35 kg, approximately 0.3-0.5 kg day^{-1}
  - Chicken live weight 1-1.5 kg, approximately 0.15-0.2 kg day^{-1}
- Animals should not be fed this fodder in the morning. They should be given this supplement fodder ration after they return from the pasture in the evening. Animals need to get used to the fodder gradually over a 4-5-day period it's gradual increase in the daily ration

Importance of hydroponicfodderover conventional/ traditional method: Hydroponic green fodder had a meaningful advantage in water use efficiency, reducing space and time, constant supplying of quality fodder, increasing forage yield, reducing forage loss and economic feasibility against conventional/traditional methods.

Efficient utilization of water: Hydroponic fodder was grown without any media except water and it is an extremely water-efficient method of a green fodder production system. Producing green fodders under hydroponic conditions is a highly efficient process in terms of water-saving when compared to field production of green fodders[10]. The hydroponic green fodder production system requires only 3-5% of water to produce the same amount of crop in soil culture[6], Only 10-20% of water is needed to produce the same amount of fodder in comparison to that produced under field conditions[23].

Save space and time: Hydroponics fodder production requires minimum land in comparison with conventional fodder production. Less land is required as the fodder is grown in trays in a vertical growing process and this optimizes the land use efficiency. They also stated that in an area of 50 m^2 under hydroponics fodder production, approximately 60 kg of fodder can be produced daily while about one hectare of land is required to produce the same amount of fodder in another fodder production option[15].

Furthermore, hydroponically produced fodder has a short growth period of 7-10 days and it does not require high-quality agricultural land and only a small piece of land is needed for fodder production[7]. To obtain nutritious fodder requires just over 7 days from seed germination to a fully-grown plant of 25-30 cm height. The biomass conversion ratio is as high as 7-8 times of traditional fodder grown for 60-80 days.

Constant supply of quality fodder: Hydroponic fodder can be produced regularly throughout the year, even when low water problems in all regions and climatic zones. Farmers using this type of fodder production are guaranteed a consistent supply of quality fodder 365 days of the year irrespective of rain, hail, sunshine, or snow.

Hydroponic fodder is a high-quality feed, rich in proteins, fiber, vitamins and minerals. The Crude Protein (CP), Neutral Detergent Fiber (NDF), acid detergent fiber (ADF) and Ca content increased, but Organic Matter (OM) and Non-Fibrous Carbohydrates (NFC) content decreased in the hydroponic green forage compared with the original seed on a DM basis[24,25,26]. Hydroponic fodder is a rich source of vitamin A, vitamin E, vitamin C, thiamin, riboflavin, niacin, biotin, free folic acid, anti-oxidants like β-carotene[8] and minerals[24] with health beneficial effects on animals[27]. Hydroponic fodder production improves nutrient content with less water, less space used and is cost-effective[28]. On the other hand, the growth of green fodder through hydroponics is completely considered as a natural source. which are free-from antibiotics, hormones and herbicides. The hydroponic technique can be used in a hygienic environment, free of chemicals like insecticides, herbicides, fungicides and artificial growth promoters, to produce green fodder for many forage crops that could contaminate animal and animal products[29].

High fodder yield: Hydroponic green fodder growing systems produce a greater yield over a shorter period in a smaller unit than traditionally-grown crops (https://www.sheepandgoat.com/hydrofodder). There is no post-harvest loss of fodder as seen in the conventional practices of hay and silage making. Will be fully utilized as there is no loss of the fodder during feeding as compared to wastag es of chopped traditional grasses. When fodder is grown in the soil, weeds cause great loss to the fodder because weeds are mostly associated with

the soil. So, eliminating soils and all bothers of weeds reduce the loss of fodder and the cost incurred for weeding. Hydroponics avoids problems shown in conventional methods of fodder production.

Marginal land use: Hydroponics fodder production requires minimum land in comparison with conventional fodder production. Less land is required as the fodder is grown in trays in a vertical growing process and this optimizes the land use. For example, research shows that fodder is grown in an area of 50 m^2 under hydroponics fodder production, approximately 60 kg of fodder can be produced daily while producing the same amount of fodder, about one hector of land is required[15]. Hydroponics greenhouse requires marginal land to erect the system, i.e., 10×4.5 m land for 600 kg green fodder/day/ unit, in comparison to one-hectare land for a conventional green grass field. Reduction in the amount of land required for maximum fodder production is an asset for both regions where agriculture is difficult and in densely populated areas that lack sufficient growing space[30].

Less workforce and transport cost: Conventional fodder production requires continuous intense labor from cultivation to the harvesting of fodder, but in hydroponics minimum man-power is required per day. Most of the farmer grows hydroponic green fodder near the livestock shade and it needs less labor force and transport cost. Depending on the size of the shed in use, research has shown that as little as 1 h per day is needed to maintain and produce hydroponic fodder. As compared to the many hours of intense labor required to grow a pasture crop, based on the size of the shed in use an hour per day is needed to maintain and produce the same amount of hydroponic green fodder. More time will be required however depending on the distances being traveled to feed the hydroponic fodder to livestock.

Economically feasible: The cost of hydroponics fodder is mainly influenced by the cost of seed and the type of system used for hydroponics fodder production . In low-cost devices, the cost of hydroponics fodder is quite reasonable. Hydroponic fodder production requires only seed and water as production inputs with modest labor inputs. It minimizes the cost of production as there is no cost of weeding, cost of herbicides, cost of pesticides and cost of fungicides used. Hydroponics minimizes post-harvest losses, with no fuel required for harvesting and post-harvesting processing. Moreover, in hydroponic systems, it takes only 7-8 days to develop from seed to fodder while it takes 45-60 days under traditional systems. Conventional fodder production also requires continuous intense labor from cultivation to the harvesting of the grass, but in hydroponics labor required is 2-3 times/day only. It needs less workforce and transport costs. Most of the farmer grows hydroponic green fodder near the livestock shade. These all make hydroponic fodder production technology economically profitable technology. Milk yield was improved by 13.7% after feeding dairy cattle on hydroponics fodder and this is due to the higher nutrient digestibility of the fodder[31].

Limitations of hydroponic fodder technology: There are many debated issues as there are claims in the use of fodder hydroponics for feeding livestock. The frequently cited limitations are following:

- Many scholars reported that, sprouting resulted in 7-47% loss in dry matter from the original seed in the period of 6-7 days mainly due to respiration during the sprouting process[24]
- Even if a low-cost hydroponic system has been developed by utilizing available infrastructure, it needs high initial investment on fully automated commercial hydroponic systems and high labour and energy costs in maintaining the desired environment in the system added substantially to the net cost of hydroponic fodder production[13]
- Mold growth is another problem in hydroponic fodder production. Controlling mold growth is important to produce healthy and safe fodder. Hydroponic fodder heavily infested with Aspergillus clavatus should not be fed to dairy/beef cattle, because it can cause decreased milk yield and possibly death[34]
- Sprouted barley fodder was 3.4 times more expensive per kg of DM than the original barley grains[23]

CONCLUSIONS

Hydroponics is an excellent technique for the cultivation of green fodder and fed in situations where cultivated fodder cannot be grown successfully and various fodder crop varieties (legumes and grasses or cereals) can be used depending on agro-ecological conditions, cost and availability of seed. It is gaining importance as it is used to guarantee a constant production of high quantity of green forage round the year for livestock. Based on the fodder producer's financial capability and preference, it can be a high-cost high-tech, or low-cost hydroponic system.

Due to great palatability, digestibility, nutritious, safe, healthy and environmentally friendly and can be fed for all types and categories of animals (cows, sheep, goats, pigs, horses, rabbits, fish and birds), hydroponic fodders become more lucrative and useful over conventional feeding of cereal grains and concentrate mixture. Hydroponic fodder improves immune status of the animals and augments productive and reproductive

performance of the livestock. It has a meaningful advantage in water use efficiency, save space and time, constantly supply quality fodder, increase herbage yield, reduce forage loss, reduce labor required and economic feasibility against conventional/ traditional methods.

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