# A comprehensive review on production and utilizations of Hydroponics Fodder

**A Production Report**

**Submitted by**


Roll no-15/07

Registration no-01420

Session-2014/2015


A Production Report is Submitted for the partial fulfillment of the Degree of Doctor of Veterinary Medicine (DVM)


## Chattogram Veterinary and Animal Sciences University

## Khulshi, Chattogram-4225

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**Approved as to style and content by**

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# ABSTRACT

Production of hydroponics fodder involves growing of plants without soil but in water or nutrient rich solution in a greenhouse (hi-tech or low cost devices) for a short duration. The use of nutrient solution for the growth of the hydroponics fodder is not essential and only the tap water can be used. Through Hydroponics techniques Oat, Maize, Wheat, Barley, Cow pea, etc. can be grown. However geographical and agro-climatic conditions and easy availability of seeds are the choice for hydroponics technology .The hydroponics green fodder looks like a mat of 20-30 cm height consisting of roots, seeds and plants. To produce one kg of fresh hydroponics maize fodder (7-d), about 1.50-3.0 litres of water is required. Yields of 5-6 folds on fresh basis and DM content of 11-14% are common for hydroponics maize fodder, however, DM content up to 18% has also been observed. The hydroponics fodder is more palatable, digestible and nutritious while imparting other health benefits to the animals. The cost of seed contributes about 90% of the total cost of production of hydroponics maize fodder. It is recommended to supplement about 5-10 kg fresh hydroponics maize fodder per cow per day. However, sprouting a part of the maize of the concentrate mixture for hydroponics fodder production does not require extra maize. Feeding of hydroponics fodder increases the digestibility of the nutrients of the ration which could contribute towards increase in milk production (8-13%). In situations, where conventional green fodder cannot be grown successfully, hydroponics fodder can be produced by the farmers for feeding their dairy animals using low cost devices.

**Key words**: Hydroponics fodder, Livestock, Production

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**List of Abbreviations:**

DM- Dry Matter

OM- Organic Matter

CP- Crude Protein

NPN- Non- Protein Nitrogen

TP- True Protein

CF-Crude Fiber

NDF- Neutral Detergent Fiber

ADF- Acid- Detergent Fiber

NFE- Nitrogen-Free Extract

NFC- Non- Fiber Carbohydrate

TDN- Total Digestible Nutrient

DCP- Digestible Crude Protein

# Chapter 1: Introduction

## 1.1 Hydroponic Techniques

Production of the natural diet for livestock, Green Fodder, to meet the current demand has become a greatest challenge among livestock farmers. Fodder production cannot easily be increased due mainly to ever increasing human pressure on land for production of cereal grains, oil seeds and pulses. Bangladesh is densely populated country with limited land resources where livestock gets very small places for grazing. It is important to serve green grass for getting increased productivity from livestock. The scarcity of animal feed and fodder has been identified as major constraint for the development of livestock in Bangladesh. Poor quality roughages having deficiencies in fermentable carbohydrates, protein, minerals and vitamins yield lower milk and meat of the animals (Migwi, 1997). At present, about 83% of the total cultivable land is used for cereal crops, where only 0.10% for cultivation of fodder crops (BBS, 2015). As a result, animal fodder shortage is aggravating day by day and recently it has emerged as an acute problem for rearing livestock in Bangladesh. In natural conditions, soil acts as a mineral nutrient reservoir but the soil itself is no essential to plant growth. When the mineral nutrients in the soil are dissolved in water, plant roots are able to absorb them. When the required mineral nutrients are introduced into a plant's water supply artificially, soil is no longer required for the plant to thrive. Almost any terrestrial plant can grow like this. This method of growing plants using mineral nutrient solutions, in water, without soil is known as hydroponics. It requires just 480 sq. ft area to produce 1000 kg every day against 5-30 acres of land under conventional system saving water by 95% (Jemimah et al.2015). It is possible by hydroponic techniques to achieve better than normal farm production, immune to natural weather variations, as well as organic and more nutritive, in just about 5% of the space and 5% of the irrigation water (Sneath et al. 2003).

The word hydroponics has been derived from two Greek words hydro means ‘water’ and ponic means ‘working’. Thus, fodder produced by growing plants in water or nutrient rich solution but without using any soil is known as hydroponics fodder or sprouted grains or sprouted fodder (Dung *et al.*, 2010a).Feeding of quality green fodder to dairy animals could play an important role in sustainable and economical dairy farming. However, various constraints are faced by the dairy farmers for production of green fodder like small land holdings, unavailability of land for fodder cultivation, scarcity of water or saline water, non-availability of good quality fodder seeds, more labour requirement, requirement of manure and fertilizer, longer growth period (45-60 days), fencing to prevent fodder crop from wild animals, natural calamities etc. Furthermore, the non-availability of constant quality of fodder round the year aggravates the limitations of the sustainable dairy farming. Due to the above constraints and the problems faced in the conventional method of fodder cultivation, hydroponics is now emerging as an alternative technology to grow fodder for farm animals (Naik *et al.* 2011).

Now hydroponics has become an established branch of agronomy and various results from different countries have proved it be thoroughly practical and have advantages over conventional methods. The major merit of hydroponics is that it potentially produces much higher yields and can be used in those places where land is not suitable or ground agriculture and gardening is not possible (Polycarpou *et al.*, 2005). Moreover, it allows a better control of water, fertilizers, climate and pest factors for crops which result in increasing productivity and economic incomes. Plants grown by hydroponics have consistently well quality, quick harvest and high nutrient content.

**Aim of report**

The aims of this report are to discuss the history, production, nutrient composition as well as utilization of hydroponics and review the relevant information.

# Chapter 2: Review of Literature

## 2.1 Hydroponic Techniques

The background of hydroponics fodder production has been provided by Sneath and McIntosh (2003). In mid-1800, Jean Boussingault, a French chemist verified nutritional requirement of plants grown without soil. By 1860, the techniques of 'nutriculture' were perfected by Sachs and Knop working independently in England. During this time, European farmers sprouted cereal grasses to feed their cows in winter. Gericke (1920-1930) developed procedures to grow plants in nutrient solution on a large scale. In 1939, Leitch reviewed a range of experiments using sprouted fodder for different livestock and poultry and stated that sprouted fodder was the commercial exploitation of water culture processes of plants to produce stock fodder. In 1969,Woodward, an English scientist, made attempt to grow plants in various sources of water. In 1970s, a range of units were designed and manufactured in many countries including Europe and USA to produce hydroponics fodder. In 1973, Harris of South Africa questioned the economics of the hydroponics system. In late 1980s, attempts were made in India for propagating hydroponics technology for forage production and research works were undertaken by several workers (Reddy *et al*., 1988; Pandey and Pathak 1991). Hydroponics technology was introduced in Goa in 2011 by establishing numbers of hydroponics fodder production units under Rashtriya Krishi Vikas Yojana (RKVY), Govt. of India by Goa Dairy at different dairy cooperative socities (Naik *et al*., 2011; Naik *et al.*, 2012a; Naik *et al.,* 2012b).

## 2.2Production of Hydroponics Fodder

Hydroponics is produced in greenhouses under controlled environment within a short period (Sneath and McIntosh, 2003). A greenhouse is a framed or inflated structure covered with a transparent or translucent material in which the crops could be grown under the conditions of at least partially controlled environment. However, the structure should be large enough to permit a person to carry out cultural operations (Chandra and Gupta, 2003). The greenhouse for the production of hydroponics fodder can be of hi-tech greenhouse type or low cost greenhouse type as per the financial status of the farmer and availability of building material.

### 2.2.1 Hi-tech greenhouse type hydroponics fodder cultivation unit

The hi-tech greenhouse type unit consists of a control unit and may be used with or without air conditioner. The control unit regulates input of water and light automatically through sensors. Although all types of fodder crops can be grown in the hi-tech green house but the routine operational cost is more particularly for sprouting the *rabi* crops (barley, oat, wheat etc.). This is because of the requirement for air conditioner in the hydroponics system to maintain cold and dry environment.

### 2.2.2 Low cost greenhouse type hydroponics fodder cultivation unit

Hydroponics fodder can also be produced in low cost greenhouses or devices (Naik *et al.*, 2013c). The low cost greenhouses or shade net structures can be prepared from bamboo, wood, MS steel or galvanized iron steel. The cost of the shade net structures depends upon the type of fabricating material but is significantly lower than the hi-tech greenhouses. One side wall of the house can be used to construct lean-to-shade net structure which reduces the cost of fabrication. The irrigation can be made by micro-sprinklers (manually or automatic controlled) or knapsack or backpack sprayer at frequent intervals. In shade net structures, the type of cereals to sprout hydroponically depends upon the season and climatic conditions of the locality. Large number of farmers are today producing hydroponics green fodder by different types of low cost greenhouses and feeding their dairy animals.

## 2.3 Crops

Different types of fodder crops *viz.* barley (Reddy *et al*., 1988), oats, wheat (Snow *et al*., 2008); sorghum, alfalfa, cowpea (AI-Karaki and AI-Hashimi, 2012) and maize (Naik *et al*., 2011; Naik *et al*., 2012a) can be produced by hydroponics technology. However, the choice of the hydroponics fodder to be produced depends on the geographical and agro-climatic conditions and easy availability of seeds. In India, maize grain should be the choice as the grain for production of hydroponics fodder due to its easy availability, lower cost, good biomass production and quick growing habit. The grain should be clean, sound, undamaged or free from insect infestation, untreated, viable and of good quality for better biomass production.

### 2.4 Seed Preparation

Soaking of seeds and the rapid uptake of water for facilitating the metabolism and utilization of reserve materials of the seeds for growth and development of the plants is a very important step for production of hydroponics forage. In case of barley (Morgan *et al*.,1992) and maize (Naik, 2012b) seeds, 4 hours soaking in water is beneficial. Under field conditions, farmers producing hydroponics maize forage have the practice of putting the seeds in a gunny bag tightly and then make it wet and keep for 1-2 days.

#### 2.4.1 Seed Rate

The seed rate also affects the yield of the hydroponics fodder which varies with the type of seeds. Most of the commercial units recommend seed rate of 6-8 kg/m2 (Morgan *et al*., 1992), however, seed rate of 7.6 kg/m2 has been suggested by Naik (2013a) for hydroponics maize fodder for higher output. If seed density is high, there are more chances of microbial contamination in the root mat which affects the growth of the sprouts.

### 2.5 Nutrient solution and water

The use of nutrient solution for production of hydroponics forage is not mandatory as it can also be produced by tap water. There are reports of non-significant improvement in the nutrient content of the sprouts which do not justify the added expense of using nutrient solution rather than fresh water (Sneath and Mclntosh, 2003; Dung *et al.*, 2010a). However, a positive response to added nutrient solution has been reported. The nutrient solution (Dung *et al*., 2010a) for hydroponics fodder production contained Ca, K, N, Fe, Mg, S, P, Zn, Mn, Cu, Bo and Na at a level of 89.20,81.90, 75.10, 1.80, 20.80, 43.20, 3.20, 0.40, 0.50, 0.01,0.10 and 0.10 ppm, respectively. It is quite interesting to note that the hydroponics forage production requires only about 3-5% of water needed to produce same amount of forage produced under field condition (AIKaraki *et al*., 2012). For producing one kg of maize fodder, about 1.50 litres (if water is recycled) to 3.0litres (if water is not recycled and drained out) of water is required (Naik *et al*., 2013c).

## 2.6 Germination and growth period

The starting of germination and visibility of roots varies with the type of seeds. In case of maize and cowpea seeds, germination starts after 1 or 2 days and the roots were clearly visible after 2 or 3 days, respectively. Photosynthesis is not important for the metabolism of the seedlings until the end of day-5 when the chloroplasts are activated (Sneath and Mclntosh,2003). Therefore, light is not required for sprouting of cereal grains however, a little light in the second half of the sprouting period encourages photosynthesis and greening of the sprouts. The grains are generally allowed to sprout for about seven days inside the greenhouse and on 8th day these are harvested as a fodder for feeding animals. Frequently, the farmers producing hydroponics fodder using low cost devices in field conditions keep the crop for 7-10 days, however, it enhances the chances of mould growth.

## 2.7 Yield of Hydroponics Fodder

For successful hydroponics fodder 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 imbibition of water (leaching) and enzymatic activities (oxidation)that depletes the food reserves of the seed endosperm without any adequate replenishment from photosynthesis by the young plant during short growing cycle (Sneath and McIntosh, 2003). In a 7-day sprout, photosynthesis commences around day-5 when the chloroplasts are activated and this does not provide enough time for any significant DM accumulation (Dung *et al.*, 2010b).Fresh yield of 2.8-8 folds in 6-8 days with DM content of 8-19.7% in hydroponics barley and fresh yield of 3.5-6.0 folds in 7-8 days with DM content of 10.3-18.5% in maize fodder, has been reported (Hillier and Perry 1969; Peer and Leeson 1985a). Farmers producing hydroponics maize fodder under low cost devices or greenhouses revealed fresh yield of 8-10 kg from one kg locally grown maize seeds in 7-10 days (Naik *et al.*, 2013b). The fresh yield and DM content of the hydroponics fodder 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, nutrient solution used, light, growing period, temperature, humidity, clean and hygienic condition of the greenhouse etc. (Trubey and Otros1969).

## 2.8 Nutrient content of Hydroponics Fodder

There are changes in the nutrient content of the cereal grains and hydroponics fodder (Hillier and Perry1969). The DM (89.7 vs. 13.4%) and OM (96.60-97.19 vs. 96.35%) content is decreased which may be due to the decrease in the starch content. The CP (8.60-13.90 vs. 11.38-24.90%), NPN(3.35 vs. 5.89%), however, the TP(7.10-9.39 vs. 7.79-8.24%) content either decreased or not affected. The increase in CP content may be attributed to the loss in DM, particularly carbohydrates, through respiration during germination and thus longer sprouting time is responsible for greater losses in DM and increase in protein content. 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 fodder higher than the tap water which may be due to the uptake of nitrogenous compounds (Dung *et al*., 2010a). The total protein content remains similar though the percentage of protein increases in the sprouted grains because of the decrease in the other components (Peer and Leeson, 1985a; Morgan *et al*., 1992). There is increase in the lysine (0.39 vs. 0.54%) content of the hydroponics fodder as there may be degradation of prolamins into lower peptides and free amino acids which supply the amino groups for the trans-amination to synthesize lysine (Peer and Leeson 1985b). The increase in EE content (1.90-4.90 vs. 2.25- 9.27%) of the hydroponics fodder may be due to the increase in the structural lipids and production of chlorophyll associated with the plant growth. The increase in the percentage of CF (2.50-10.10 vs. 7.35-21.20), ADF (7.00-8.90 vs. 14.35-28.20); and decrease in the NFE (27.00-84.49 vs. 48.90-68.85) and NFC (61.55-64.65 vs. 43.00-49.03) may be attributed to the increase in the number and size of cell walls for the synthesis of structural carbohydrates. During the sprouting process, the total ash content (1.57-3.40 vs.3.65-5.50%) is increased due to the decrease in the OM. Morgan *et al.* (1992) found that the ash content of sprouts increased from day-4 corresponding with the extension of the root which allowed the mineral uptake.

The ash content of the sprouts increases more ,if nutrient solution is used rather than water which may be due to the absorption of minerals by the roots (Dung *et al.,* 2010b). The nutrient contents of hydroponics fodder are superior to certain common non-leguminous fodders but comparable to leguminous fodders (Reddy *et al*., 1988; Pandey and Pathak, 1991; Naik *et al*., 2012a) in terms of available OM, CP, EE and NFE conten

### 2.9 Feeding values of Hydroponics Fodder

Hydroponics 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 (Pandey and Pathak, 1991).Sometimes, animals take the leafy parts of the hydroponics fodder and the roots portions are not consumed which can be avoided by mixing the hydroponics fodder with the other roughage components of the ration (Reddy *et al.*, 1988, Naik *et al.*, 2014).However, there are reports of decrease in the DM intake of the animals (Table 1) when hydroponics fodder is fed (Fazaeli *et al.*, 2011; Naik *et al.*, 2014).Feeding of hydroponics fodder increased the digestibility of the nutrients of the ration which could be attributed to the tenderness of the fodder (Reddy *et al*., 1988; Naik *et al.*, 2014). The digestibility of the nutrients of the hydroponics fodder was comparable with the highly digestible legumes like berseem and other clovers (Pandey and Pathak, 1991). The DCP and TDN contents of the hydroponics barley fodder were optimum to meet the production requirement of the lactating cows (Reddy *et al.,* 1988).The milk yield was improved by 7.8-13.7% by feeding of hydroponics fodder which might be due to the higher nutrient digestibility (Reddy *et al*., 1988; Naik *et al*., 2014). The cost of the hydroponics fodder is mainly influenced by the seed cost as it contributes about 90% of the total cost of production (Naik *et al.,* 2012b). In low cost devices where seed is grown at the farmers' field, the cost of the hydroponics fodder is quite reasonable. The farmers' feedback revealed increase in milk production, improvement in general fertility, conception rates, appearance of coats or fleece, general animal health etc.(Anonymous, 2012; Anonymous, 2013; Naik *et al*.,2013b).

**Table 1. Effect of feeding of hydroponics fodder on intake and digestibility of nutrients**

| Parameter | Hydroponics fodder | | Reference |
|---|---|---|---|
| **Feed intake** | **No** | Yes | Reddy *et al*. (1988)<br>Pandey and Pathak (1991)<br>Fazaeli *et al*. (2011)<br>Naik *et al*. (2014) |
| Fresh intake (kg/d) | --- | 50.38 | |
| DM intake (kg/d) | 7.20-9.70 | 6.60-8.85 | |
| DM intake/100 kg BW (kg) | 2.17-2.84 | 2.05-2.74 | |
| Roughage: concentrate ratio | 63:37 | 65:37 | |
| **Digestibility (%)** | | | |
| DM | 60.34-8.85 | 64.48-65.53 | |
| OM | 61.89-64.19 | 65.98-68.47 | |
| CP | 61.89-68.86 | 66.77-72.46 | |
| EE | 69.92-82.05 | 77.60-87.69 | |
| CF | 47.93-53.25 | 54.85-59.21 | |
| NFE | 65.84-67.37 | 68.13-70.47 | |
| **Nutritive value (%)** | | | |
| DCP | 6.89-8.61 | 7.82-9.65 | |
| TDN | 55.43-64.00 | 61.19-73.12 | |
| **Nutrient intake (kg/d)** | | | |
| CP intake (kg/d) | --- | 0.97 | |
| DCP intake (kg/d) | --- | 0.67 | |
| TDN intake (kg/d) | --- | 5.20 | |

### 2.9.1 Potential health benefits of Hydroponics Fodder

The potential health benefits of hydroponics fodder are well known since long (Sneath and Mclntosh,2003). Dry grains contain abundant enzymes which are mostly inactive due to the enzyme inhibitors. During sprouting, the activities of the inactive enzymes of the grains are increased due to the neutralization of the enzyme inhibitors and these enzymes ultimately break down the reserve chemical constituents such as starch, protein and lipids into various metabolites *viz.* sugars, amino acids and free fatty acids. Furthermore, these are used to synthesise new compounds or transported to the other parts of the growing seedling including the breakdown of nutritionally undesirable constituents (Chavan and Kadam, 1989). The enzymes cause the inter-conversion of these simpler components leading to increase in the quality of the amino acids and concentration of the vitamins (Plaza *et al.*, 2003;Koehler *et al.*, 2007). Sprouts are rich source of anti-oxidants in the form of β-carotene, vitamin-C, E and related trace minerals such as Se and Zn. As sprouted grains (hydroponics fodder) are rich in enzymes and enzyme-rich feeds are generally alkaline in nature, therefore, feeding of the hydroponics fodder improves the animals' productivity by developing a stronger immune system due to neutralization of the acidic conditions. Besides, helping in the elimination of the anti-nutritional factors such as phytic acid of the grains, hydroponics fodders are good source of chlorophyll and contain a grass juice factor that improves the performance of the livestock (Finney,1982).

## 3.0 Advantage of hydroponic green fodder production at a glance

i. **Nutritional Advantages:** The green fodder from hydroponics is highly palatable, easily digestive and of better quality as compared to traditional fodder production. In comparison to conventional green fodders, Hydroponics Green Fodder (HGF) contains more crude protein (13.6% v/s 10.7%) and less crude fibre (14.1% v/s 25.9 %) as compared to traditional fodder production.

ii. **More Palatability:** The fodder is more succulent, palatable, nutritious and intake HGF by livestock is more as compared to CGF and this results in more milk and meat production.

iii. **Water savings**: Hydroponic techniques require 2-3 litres of water to produce one kilogram of green fodder as compared to 55 to 75 litres of water required for the traditional Cultivation practices. No wastage of water as the available water is also recycled and utilized.

iv. **Wider temperature range**: Temperature range of 15-35°C and 70-80% relative humidity (RH) without any fungal growth and technology is economic and environmental friendly.

v**. Minimal Land requirement**: only 10 m X 5 m is required to grow 600-650 kg of fodder per day whereas to produce the same quantity, one hectare of land would be required under traditional cultivation system. 20-25 adult cattle can be reared by this quantity of fodder for one year.

vi. **Easily Measurable**: The hydroponics production can easily be measured to cater to the needs of farmers owning just two head of cattle.

vii. **Less labour required**: Under the HGF system, just one labour can complete the entire

process in 2-3 hours per day whereas for same fodder production through tradition system requires more labour to undertake land preparation, sowing, irrigation, cutting, transporting fodder from field to cattle shed, cutting the chaff and finally feeding the cattle.

viii. **More fodder in less time**: Just 7-8 days is required for HGF when they are about 20 to 30 centimeter in height.

ix. **Biomass conversion is more**: The biomass conversion ratio is as high as 6-7 times that of the CGF grown for 65 to 80 days.

x. 365 Day in a year fodder production: 365 days in year we can produce green fodder under semi-protected conditions.

xi. **Minimal losses**: Loss is minimal because the whole portion of plant comprising of roots, leaves, grain and stem is fed to the animals.

xii. **Organic/natural green fodder**: Due to non-adding of any nutrient without using soil the green fodder is organically grown.

xiii. **Higher growth and More Production**: Green fodder production at a faster rate and result in high yield of fodder

### 3.0.1 Comparison of green fodder cultivation using hydroponics and conventional land based cultivation

| Parameter | Conventional Land Based Fodder Cultivation | Hydroponics Systems |
|---|---|---|
| Area required | 1 hac. land to produce 600 kg/day | 50 sq mt to produce 600 kg/day |
| Fodder production in days | 65-70 days | 7 days |
| Water requirement | Very high at 30 litres per kg of green fodder | Minimal at just 1.5 to 3 litres per kg of green fodder |
| Soil fertility | Essential | Not required |
| Fertilizer application | Required | Not required |

### 3.1Some precautions for hydroponic techniques

1. Seed treated with pesticides and fungicides should not be used for cultivation.
2. The water should be replaced at every 3 days to reduce microbial contamination.
3. In order to avoid fungal growth, cleanliness, washing and cleaning should be needed to reduce contamination and fungal growth. Fungicides treatment is needed while necessary but should best be avoided as any residue may adversely affect health of animals.
4. White maize seed better as compared to yellow maize for hydroponic fodder production.
5. The quality seeds should be used for fodder cultivation.
6. The green shed net is important for proper aeration and lighting to prevent yellowing of the leaves.

# Chapter 4: Conclusions

There seems to be a great potential for developing hydroponics technology for fodder production. Hydroponics fodder can be produced and fed in situations where cultivated fodder cannot be grown successfully. The technology can also be adopted by progressive modern dairy farmers with elite dairy herd and produce hydroponics fodder for feeding their dairy animals. However, further research is needed to develop low cost devices for the fodder production through this technology using locally available materials.

**Figure:** Hydroponic techniques for fodder production.

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