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Review Article

Hydroponic Techniques for Fodder Production

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Abstract

Growing of plants without soil but in water or nutrient solution in a greenhouse (hi-tech or low cost devices) for a short duration (approx. 7-8 days) is hydroponics fodder Production. In India, maize grain is preferred over other cereal grains for hydroponics fodder production. The hydroponics green fodder looks like a mat of 20-25 cm length consisting of roots, seeds and stems. 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 has more health benefits due to its palatability, easily digestibility and and nutritious. Seed for hydroponic cultivation is major input contributes about 90% of the total cost of production of hydroponics. 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. Supplementation about 5-10 kg fresh hydroponics fodder per cow per day increases milk production (8-13%) by increases in the digestibility of the nutrients.

Keywords: DM: Dry Matter; HGF: Hydroponics Green Fodder; CGF: Conventionlly Grown Fodder

Introduction

In India, livestock plays an important role for the nutritional security, particularly of the small and marginal farmers. As per the 19th Livestock census 2012, the livestock population of the country is 529.70 million including 199.08 million (37.59%) cattle, 108.7 million (19.89%) buffaloes, 71.56 million (13.51%) sheep, 140.54 million (26.54%) goats and 11.00 million Pigs. The growth rate during last 56 years (1951-2007) shows increasing trend in cattle (28.19%), buffaloes (142.72%), sheep (83.02%) and goat (197.76%) and the overall growth rate in livestock is 80.91% [1]. The increase in the livestock population along with the intensive rearing system has resulted in the increase demands for feeds and fodder in the country. The feed scarcity has been the main limiting factor in improving the livestock productivity [2]. The land allocation for cultivation of green fodder is limited to only 5% of the gross cropped area; but by 2020, India would require a total 526, 855 and 56 million tons of dry matter, green fodder and concentrates [3].

In India Livestock contributes about 25% of the total agricultural GDP and plays a major role in the lives of small and marginal farmers and landless labours agriculture based economy. Green fodder considered as vital inputs in livestock activities as it provides required nutrients for milk and meat production and helps maintain the health of the animals. Feeding cost in dairy and meat animals impacts the profit and results in successful animal husbandry farming, if we will save the concentrates there is more profit. Green fodder constitutes 13 to 35% of the total input cost out of total feed cost is about 70 to 75%, of the total cost. Green fodder supply around the year is required for Good dairy practices. The National Dairy Development Board recommends that a cow yielding 8 to 10 litres of milk per day be fed 25 to 30 kg of green fodder, 4 to 5 kg of dry fodder and 4.0 to 4.5 kg of concentrate per day during lactation [4].

The unavailability of quality green fodder adversely affect the productive and reproductive efficiency of the livestock. Besides the less availability of land, more labour for cultivation (sowing, earth-

ing up, weeding, harvesting etc.), more time for harvesting, non-availability of same quality around the year, requirement of manure and fertilizer; the uncertainty of rain fall, water scarcity and natural calamities due to climate change are the major constraints for green fodder production encountered by the livestock farmers. Due to the above constraints the hydroponics technology is coming up as an alternative to grow fodder for farm animals [5-7]. Further, hydroponics technology for fodder production will be very effective for rearing small ruminants (sheep and goats) as these animals have lesser DM requirement and are being shifted from extensive to intensive rearing system.

Following are the reasons for scarcity of green fodder

1. Rapid urbanization has caused decrease of land available for grazing and fodder cultivation.
2. Fragmentation of land reduces land holdings.
3. The farmer prefers to cultivate commercial and food crops.
4. There is a scarcity of water for irrigation, due to water label depletion.
5. Most farmers are poor and not able to fence their land which leads to free grazing cattle and wild animals enter the fields and causes menaces in the fodder field.
6. Labour shortage is an acute problems in agriculture and animal husbandry allied activities.eg cultivation of green fodder, cutting, chaffing it and feeding the same to the cattle.
7. In forest areas/coastal areas adequate land are not available for forage cultivation.
8. In diversified climate of India, the climate is not suitable for fodder production.

Hydroponics technology for fodder production

The word hydroponics has been derived from the Greek word, "Hydros" meaning 'water' and "Ponic" meaning 'working'. Hydroponics is a technique in which growing of plants/crops in water without any soil, generally in controlled conditions/environment. Water and plant nutrients are essential for plant growth which is incorporated.

However, with the use of only fresh water green fodder can be produced. For cultivation of green fodder through hydroponic seed, water sunlight and added nutrients are the only inputs that are required as the green fodder is fed to the animals after about 6-8 days of plant growth. Maize, Oats, Barley, Wheat, Cowpeas, etc., are the important cultivars using hydroponics to produce high quality nutritious green fodder for dairy animals. Sorghum when fed, less than 45 days of growth causes prussic acid (HCN) toxicity so it is not preferred in hydroponic fodder production.

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. In India, easy availability of seed, lower seed cost, good biomass production and quick growing habit, maize is the choice of grain for hydroponics fodder production. The grain should be clean, sound, undamaged or not insect infested, untreated, viable and good quality. For the production of hydroponics fodder, seeds are soaked in normal water for 4-24 hours, depending upon the type of seeds followed by draining and placing it in the individual greenhouse trays for growing inside the greenhouse. For maize, 4 hours soaking in normal water is sufficient. The seed rate (quantity of seeds loaded per unit surface area) also affects the yield of the hydroponics fodder, which varies with the type of seeds. Hydroponics maize fodder can be well produced with seed rate of 6.4-7.6 kg/m2 [8]. If seed density is high, there is more chance of microbial contamination in the root mat, which affects the growth of the fodder. The starting of germination and visibility of roots varies with the type of seeds. In case of maize and cowpea seeds, germination start on about 2nd and 1st day and the roots were clearly visible from 3rd and 2nd day onwards, respectively. Maintenance of clean and hygiene is very much important in the production of hydroponics fodder as greenhouse is highly susceptible to microbial contamination, particularly of mould growth due to high humidity. Inside the greenhouse, generally the grains are allowed to sprout for seven days and on day eight, these are fed to the dairy animals.

Advantage of hydroponic techniques of green fodder production

1. **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.
2. **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.
3. **Water savings:** Hydroponic techniques requires 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.

4. **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.
5. **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.
6. **Easily Measurable**: The hydroponics production can easily be measured to cater to the needs of farmers owning just two head of cattle.
7. **Less labour required:** Under the HGF system, just one labourer 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.
8. **More fodder in Less time:** Just 7-8 days is required for HGF when they are about 20 to 30 centimetre in height.
9. **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.
10. **365 Day in a year fodder production:** 365 days in year we can produce green fodder under semi-protected conditions.
11. **Minimal losses:** Loss is minimal because the whole portion of plant comprising of roots, leaves, grain and stem is fed to the animals.
12. **Organic/natural green fodder:** Due to non adding of any nutrient without using soil the green fodder is organically grown.
13. **Higher growth and More Production:** Green fodder production at a faster rate and result in high yield of fodder.

Comparison table of green fodder cultivation using hydroponics and conventional land based cultivation

S.	Parameter	Conventional Land Based Fodder Cultivation	Hydroponics Systems
1	Area required	1 hac. land to produce 600kg/day	50 sq mt to produce 600kg/day
2	Fodder production in days	65-70 days	7 days
3	Water requirement	Very high at 30 litres per kg of green fodder	Minimal at just 1.5 to 3 litre per kg of green fodder
4	Soil fertility	Essential	Not required
5	Fertilizer application	Required	Not required
6	Fodder yield	Dependent on environment, cultivation practices, etc	Controlled conditions
7	Labour requirement	Intensive for sowing, harvesting, chaffing, etc	Minimal
8	Fencing and farm protection	Essential	Not required – can be undertaken in small shed or even under shade net
9	Green fodder utilization	Significant Wastage	Complete- almost no wastage

Table a

Naik., *et al.* [9]

Techniques for production

The HGF cultivation can be hi-tech, fully automatic or can be low cost, effective structure by using principle of the seed germinating and growing for about 7 to 8 days using only water till they are about 20 to 30 cm in height.

An automatic system has chambers in which foggers or drip irrigator are installed. The relative humidity between 70 and 80% are maintained and foggers spray a fine mist of water on to the trays to keep the seeds moist. However, for the Indian farmer low cost effective sustainable system are needed as per local need of input. According to availability of raw material in local areas both scientists and ordinary farmers have modified the way hydroponics fodder production.

A specially constructed frame made of GI pipes or angle bars is erected to hold plastic trays measuring 18" X 32.5" X 2", in which 1 to 1.25 kg of seed can be placed to produce about 5.5 to 7.5 kg of green fodder. The dimensions of the trays is determined so that they can be easily managed by anyone and other standard sizes

such as 41" x 41" x 7", 53" x 53" x 7", 29"x 53" x 7", etc., that are available in the market can also be used.

1. To reduce the cost the netshed can be erected using bamboo, locally available pipe, wood and instead of trays, bamboo baskets can be used.
2. The shade net cloth is used to cover the entire chamber.
3. An arrangement of frame designed or drip irrigation pipes can be used to pump water from a reservoir at the bottom to pipes in which holes have been punched. The water dribbles drop by drop continuously.
4. 4 hours soaking is required to treated maize seed before cultivation.
5. In each tray about 1 to 1.25 kg of soaked maize seed is spread out.
6. At the end of 7-10 days, plants measuring about 20 to 30 cm in height.
7. About 7.0 kg and 7.5 kg of green fodder is produced in 7 to 8 days and production cost per kg fodder is Rs. 3 to 4 as per availability of seed.
8. The cost of a PVC pipe shade net HGF production unit capable of producing 30 kg fodder/day is about Rs.15,000 while that producing about 350 kg/day is about Rs.80,000 while that of a GI pipe/angle bar/MI steel shade net unit with a daily fodder production potential of 300 kg is about Rs. 60,000 increasing progressively to Rs.3,00,000 for a unit producing 1500 kg.

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.

Yield, Palatability, Nutritive Value and Digestibility of the Hydroponics Fodder

There is increase in fresh weight and decrease in the dry matter content during sprouting of seeds. Yields of 5-6 folds on fresh basis (1 kg seed produces 5-6 kg fodder) and dry matter content of 11-14% are common for hydroponics maize fodder; however, sometimes dry matter content up to 18% has also been observed [10]. Famers of the Satara district of Maharashtra revealed fresh yield up to 8-10 folds for hydroponics maize fodder in shade-net greenhouse system. The yield and dry matter content are influenced by many factors, mostly the type and quality of the seed; degree of drainage of free water prior to weighing; and clean and hygienic condition of the greenhouse. The fodder obtained from hydroponics techniques looks like a mat of 20-30cm height consisting of germinated seeds embedded in their white roots and green shoots. In Goa condition with hi-tech greenhouse, the cost of production of fresh hydroponics maize fodder is about Rs. 4.-4.50/kg [11], in which the seed cost is about 90-98%. However, farmers of the Satara district of Maharashtra revealed that in low cost shade net system with home-grown or locally purchased seeds, the cost of production of the hydroponics fodder is very minimal and reasonable (about Rs.2-3.50/).

The hydroponics fodder is more nutritious and palatable than the conventional fodder (Table 1 and 2). The nutrient changes during the growth (sprouting) of hydroponics fodder are increase in the crude protein (CP), ether extract (EE), nitrogen free extract (NFE) and decrease in crude fibre (CF), Neutal detergent fibre (NDF), total ash (TA) and insoluble ash (AIA). Fodder is a high quality supplement for livestock diet.

Besides, hydroponics fodder has more potential health benefits. Sprouts are the most enzyme rich food on the planet and the period of greatest enzyme activity is generally between germination and 7-8 days of age. They are rich source of anti-oxidants in the form of β-carotene, vitamin-C, E and related trace minerals such as selenium and Zn (Table 2). Feeding of the sprouted grains improve the animals' productivity by developing a stronger immune system due to neutralization of the acidic condition due to sprouted grains are rich in digestive enzymes and enzyme-rich feeds are generally alkaline in nature. Sprouted grains are good sources of pigments containing chlorophyll, xanthophil and contain a grass juice factor and protein spairying factors which improves the production and reproductive performance of the livestock. Besides this, helping in the elimination of the anti-nutritional factors such as phytic acid, oxalic acid and other toxicants of the fodder. However, the energy content is decreased during sprouting as the stored energy inside the grain is used and dissipated during the process [12-16].

The hydroponics fodders have relished by cattle, horses young growing calve due to softness and palatability. The germinated

seeds embedded in the root system are also consumed along with the shoots of the plants, so there is no nutrient wasting. The intake of fresh hydroponics maize fodder by dairy cows may be up to 25 kg/animal/day along with limited concentrate mixture and jowar straw. Supplementation of the hydroponics fodder in the ration of the dairy cows improves digestibility of nutrients in dairy cows (Table 1).

S.N.	Parameters	Hydroponics Fodder
Digestibility (%)		
1	Dry matter	61.15
2	Organic matter	64.20
3	Crude protein	68.86
4	Ether extract	82.05
5	Crude fiber	53.25
6	Nitrogen free extract	67.37
Nutritive value (%)		
1	CP	12.48
2	DCP	8.61
3	TDN	64.00
4	Milk yield (kg/ day)	4.084

Table 1: Effect of supplementation of hydroponics maize fodder on digestibility of nutrients and milk yield of dairy cows.

Naik., *et al.* [17].

There are reports of increase in milk yield of 7.8% and 9.3% (FCM yield) [18]; 12.5% (Anonymous, 2012) and 13.73% [17] due to feeding of hydroponics fodder to lactating cows.

The feedback from the farmers of the Satara district of Maharashtra revealed increase in the milk yield by 0.5-2.5 litres per animal per day and net profit by Rs. 25-50/- per animal per day due to feeding of hydroponics fodder to their dairy animals. Besides, the other advantages observed by the farmers were increase in fat and SNF content of the milk, improvement in health and conception rate of the dairy animals, reduction in cattle feed requirement by 25%, increase in taste (sweetness) of the milk, whiter milk, reduction in labour cost, requirement of less space and water, freshness and high palatability of the hydroponics fodder etc [19].

Nutrients	% Composition	Nutrients	% Composition
Moisture	89%	Nitrogen	4.6%
Calcium	0.167%	Protein	29.87%
Magnesium	0.246%	Sodium	0.117%
Potassium	2.22%	Phosphorus	0.91%
Manganese	53 mg/kg	Copper	28 mg/kg
Zinc	56 mg/kg	Iron	235 mg/kg

Table 2: Plant Analysis report of Hydroponic fodder carried out by the Environment Analysis Laboratory at the University of Lismore, NSW. (All analysis on Dry weight/Matter Basis).

Figure

Conclusion

Hydroponics fodder is nutritious, palatable and digestible and can be grown in low cost techniques with locally home grown grains. Against impeding climate change and less availability land hydroponics fodder production is an effective alternative technology for sustainable livestock production in different agroclimatic regions of India.

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Volume 3 Issue 5 May 2019