Hydroponics: A sustainable way of green fodder production

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Hydroponics:

A sustainable way of green fodder production

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India's fodder deficits are driving down its livestock productivity, especially in terms of milk and meat yields. Quality feeding of livestock is a major concern in our country due to the continuous shortage of green fodder and increased cost of feed ingredients; as a result, livestock owners are searching for easily accessible and affordable alternatives. The hydroponic technique is one such alternative method for growing green fodder for dairy animals. Hydroponic fodder production involves growing plants in a greenhouse or polyhouse without soil but in a water or nutrient-rich solution for a short period of time (approx. 7 days). It is gaining importance as it is used to guarantee a constant production of high quantity green forage round the year. Since hydroponics fodder is more palatable, digestible and nutritious, it improves the immune status of the animals, and augments their productive and reproductive performance. Thus, hydroponic fodder can become the best alternative to feed livestock to improve their productivity.

Keywords: Green fodder, Hydroponics, Livestock, Sustainable

As per the 20th Livestock census (2019), India is having 536.5 million livestock population, which is 11.6% of the world's livestock population. The growth rate during the last 56 years in livestock is 80.91%. This increased growth rate of livestock demands an increase in the fodder production required to maintain sustainability in livestock production. But there is a clear gap between the need and production of feed since the land allocation for green fodder production is limited to only 5.4% (8 mha) out of the total gross cropped area in our country. Lack of quality feed and fodder is a major concern which limits the productivity of livestock. Currently, India is facing a deficit of 35.6% of green fodder, 26% of dry fodder and 41% of concentrate feed ingredients. Green fodder is a critical constituent in the dairy ration for optimum productive and reproductive performance. However, the major constraints in green fodder production are the unavailability of land, water scarcity, climate change, shortage of labour, the requirement for manure and fertilizer, and more growth time. Considering these constraints, hydroponics technology is coming up as an alternative to produce green fodder for dairy animals.

Hydroponics is the science of growing plants in nutrient-rich solutions instead of soil and has proven to be efficient both financially and environmentally. Hydroponic methods have been in use for a long to grow plants, primarily vegetables, but now they are being used across many countries to take pressure off the land and to grow green fodder round the year for livestock. Many livestock farmers are switching to hydroponic fodder production from conventional production methods, as the fodder produced by this method is highly nutritious, and conserves water. Additionally, animal production may become more profitable because the resulting fodder's nutritional qualities have changed (becoming richer in sugars, vitamins and lysine while containing less starch). The presence of important micronutrients and other phytonutrients may have added advantage in optimizing the health and reproduction of farm animals. Furthermore, the quality of the livestock products (meat and milk) may also be improved with enhanced contents of omega-3 fatty acid (ω3) and conjugated linoleic acid (CLA). It is a viable farmer-friendly alternative technology for landless farmers.

Fodder crops suitable for hydroponics

Yellow maize, cowpea, horse gram, sun hemp, ragi, bajra, foxtail millet and jowar have been grown successfully as livestock fodder. However, maize is the most preferred fodder crop due to its 5–6 times higher yield than the conventionally grown maize. Leguminous crops grow well and are more encouraging as fodder owing to their high crude protein

content than cereal crops. Green fodder obtained from hydroponics consists of grass with grains, roots, stems and leaves, and is found to be highly palatable with no wastage. Whereas conventionally grown fodder consists of a stem and leaves only. Hydroponically grown fodder can be fed to cattle, buffalo, sheep and goats, and chickens, ducks and rabbits.

Cultivation of hydroponic fodder

Seed preparation and washing: Good quality seeds should be selected for hydroponic system as seed cost (85–90%) is the major capital in the hydroponic fodder production system. The use of broken or damaged or unhealthy seeds should be avoided as they will not grow and germinate properly. Seeds should be dried directly under sunlight one day prior to seed washing. Then washing should be done for 5 minutes with tap water till all dirt and poor-quality seeds are removed. The seeds of various fodders should be soaked in a stimulant solution containing 0.1–1.5% sodium hypochlorite or 1–2% hydrogen peroxide for a period of 20, 12, 10, 6 and 15 hours for maize, jowar, barley, wheat and bajra respectively. Drained off the cleaning solution and the seeds are then washed in tap water. Also add 50–100 gm salt in water as it helps in minimizing fungus growth on the sprouted seed.

Seed soaking: The seeds are soaked in fresh aerated water for different periods like 4 h, 8 h, 12–16 h, or overnight, depending on the hardness of the seed coat. Otherwise, add seeds in a bucket containing 5–7 litres of warm water and remove seeds that floats on the water as they will not sprout, and remove impurities. The temperature of the water or solution used for soaking also affects the germination rate. The optimum temperature for soaking is 23°C.

Germination of seed: After soaking, spread the seeds at up to 1 cm depth in plastic or lightweight metallic trays with holes to facilitate drainage of the wastewater/nutrient solution, which can be collected in a tank and recycled. A nutrient solution for hydroponic systems is an aqueous solution containing mainly inorganic ions plays a vital physiological role to complete the plant life cycle. The seed rate (quantity of seeds loaded per unit surface area), varies with the type of seeds and also affects the yield of the fodder. The recommended seeding rate for the production of hydroponic barley, wheat or sorghum fodder is 4–6 kg/m^2 and for maize is 6.4–7.6 kg/m^2.

Environmental factors: The environmental factors are important for optimization of the hydroponic fodder growth and production. The standard level of environmental parameters such as temperature (19 to 22°C), humidity (average 60%), light intensity (2000 lux), length (12–16 h and aeration for 3 minutes at every 2 hour interval) should be maintained. In cold climatic conditions, wheat and oats seeds are good, while in hot climatic conditions, maize seeds are suitable for hydroponic fodder production.

Washing and soaking (12 hrs) of maize seeds
Source: http://vadic.vigyanashram.blog/wp-content/uploads/2019/03/day-7-1024 x 577.jpg

Fodder trays place in hydroponic unit system
Source: https://www.hydroponicsafrica.org/wp-content/uploads/2020/10/Fooder.jpg

Loading seeds in trays and racking: A specially constructed frame made of GI pipes or angle bars is erected to hold plastic trays measuring 46 cm × 83 cm × 5 cm in which 1–1.25 kg of seed can be placed to produce about 5.5–7.5 kg of green fodder. Other standard sizes of trays such as 104 cm × 104 cm × 18 cm, 135 cm × 135 cm × 18 cm, 74 cm × 135 cm × 18 cm are also available in the market. The seed trays should be clean, washed with a cleaning solution and are free from any dust/dirt. After the germination of seeds, trays are transferred and put in the sprout section (a lower section where the height between two rows is around 5 inches). Finally, trays should be distributed evenly on both sides of the alley.

Watering and shifting trays: The germinated seeds are irrigated with fresh tap water or nutrient-enriched solution. The trays should never be exposed to direct sunlight, strong wind and heavy rain. During the growing period, kept the seeds moist by drip or spray irrigation but not saturated. In hot weather conditions, water should be given after every 2 hours and in cold weather conditions after every 4 hours. Shift trays to the next level daily so that it moves one step ahead in the growth cycle. The sprouted seeds in trays should not be disturbed until they are harvested otherwise their growth will be affected.

Hydroponic green fodder production
Source: Feedipedia

Low-scale hydroponic fodder unit
Source: https://agriculturegurui.com/wp-content/uploads/2018/10/Hydroponic-fodder-system.jpg

Harvesting and feeding: After 7–8 days, the fodder mat is harvested from the tray and fed to the livestock. Before feeding, the fodder mat should be divided into small pieces so that the animals can consume it easily. Hydroponic fodder can be fed to dairy animals by mixing it with other dry roughage. As per one study, feeding of 5–10 kg of hydroponic fodder daily to dairy cows increased milk production by 8–13%, because of its palatability and enhanced digestibility. In other study conducted at the Anantapur district of Andhra Pradesh, the cows were fed with 18 kg hydroponically grown maize fodder along with 7 kg jowar straw every day. The results indicated that there was an increase of 7.51% in milk yield with an additional net income of ₹35 per day. It also reduced the requirement for concentrates thus lowering the cost of milk production.

Nutritive value

Sprouting catabolizes starch into soluble sugar during the biochemical processing of plants. As a result, the starch content, organic matter and dry matter content decreases. However, as the plant grows the ether extract of hydroponic fodder increases due to the increment of structural lipids and chlorophyll (Table 1). There is also an increment in concentration with sprouting. The development of structural carbohydrates increases the concentration of crude fibre (CF), neutral detergent fibre (NDF), acid detergent fibres (ADF), and linoleic acid but decreases nitrogen-free extract (NFE). The sprouting process increases total ash content associated with the decrement of organic matter. Root growth not only increases the mineral uptake but also increases the mineral content of the sprout from day 4 and evidently more as the nutrient solution is used instead of water. The sprouts are the most enzyme-rich plants and maintain the highest level from germination to 7 days of age. They are rich in antioxidants, especially carotene.

Hydroponic maize fodder after 7 days
Source: http://vadic.vigyanashram.blog/wp-content/uploads/2019/03/day-7-1024 x 577.jpg

Uses/potential benefits

- Hydroponic technology is eco-friendly.
- The hydroponic system allows growing green fodder at a wider temperature (15–32°C) and humidity range (80–85%) without fungal growth.
- Hydroponically grown fodder is highly nutritious and free from contamination.
- It saves water and labour cost.
- The green fodder from the hydroponic system improves animal/livestock health and reproductive efficiency.

Precautions for cultivation

- The seeds should be procured from a certified organization to be used for cultivation.
- Seeds treated with pesticides and fungicides should not be

Table 1. Nutrient composition (Per cent dry matter basis) of hydroponics maize fodder

Nutrient	Maize seed (0 day)	Days of sprouting under hydroponic system							Conventional maize fodder
		1	2	3	4	5	6	7	
Crude protein	8.60	8.88	9.14	9.65	11.27	11.58	12.89	13.57	10.67
Ether extract	2.56	2.49	2.57	2.88	3.08	3.06	3.21	3.49	2.27
Crude fiber	2.50	2.55	3.07	4.72	5.51	7.56	10.67	14.07	25.92
Nitrogen free extract	84.49	84.15	82.87	79.20	77.65	74.04	69.21	66.72	51.78
Total ash	1.57	1.67	1.84	1.92	2.19	2.44	3.34	3.84	9.36
Acid insoluble ash	0.02	0.03	0.08	0.09	0.13	0.14	0.24	0.33	1.40

Source: Naik *et al*. 2015

Table 2. Comparison between hydroponically grown green fodder and conventional green fodder

Attribute	Hydroponics green fodder	Conventional green fodder	Savings on
Area	Less land	More land	Land
Fodder production in days	Just 7 days	65 to 70 days	Time period saving
Water and electricity requirement	Very low 2-3 litres/kg green fodder	Very high 30 litres/kg green fodder	Water and electricity saving
Soil fertility	Not essential	Essential	Saves the fertility requirement
Fertilizers	Not required	Required	Saving on fertilizers cost and protects from contamination
Fodder yield dependency	In controlled environment	On climate, Irrigation	No dependency on external factors
Labour requirement	Very less	More	Saving on labour
Fencing and protection	Not required	Required	Saving on labour
Green fodder utilization by animals	Completed/Full	Partial	Reduction in green fodder waste

used for cultivation as any residue may adversely affect the health of animals.

- The water should be replaced at every 3 days to reduce microbial contamination.
- The green shed net is important for aeration and lighting to prevent yellowing of the leave because the green shade net allows sufficient light and maintains favourable temperature and humidity for optimum photosynthesis which results in a better yield of hydroponic fodder.

Economic benefit

As compared to the conventional forage production system, hydroponic fodder production is an economically feasible method for dairy farmers as it reduces the cost of cultivation by minimizing the use of electricity, land, water, labour, insecticides, weedicides, fertilizer and pre, and post-harvest machinery (Table 2). Farmers can be economically benefited by taking up small-scale hydroponic fodder units (25–100 kg/d) with an initial investment of ₹30,000–35,000. It will also help in reducing the concentrate feeding cost, if replacing the part of the concentrate with hydroponic fodder. The feed cost/kg milk can be reduced up to 25–30% by feeding hydroponic fodder. In the Satara district of Maharashtra, dairy farmers noticed the reduced cost of milk production by ₹2–3.5/kg feed and improved milk yield by 0.5–2.5 litre/animal/day on feeding hydroponic fodder.

Way forward

Hydroponic fodder is definitely going to be a lifeline for the Indian dairy system, which can address the problem of acute feed and fodder deficiency in areas having water scarcity, limited land for cultivation, extreme seasonal variations, high transport rates and fuel prices. Especially for small and marginal farmers, this method of fodder production is very much useful in the lean season. Government should provide income support through a dedicated scheme for dairy farmers to set up small-scale units to encourage hydroponic fodder production. Farmers should be educated by conducting more field training and demonstrations for better results. As the livestock population is increasing due to the increased demand for livestock products, the requirement for the fodder in near future will be doubled. So, it will provide an opportunity for young entrepreneurs to set up large-scale hydroponic fodder production units and market the produced fodder through the e-commerce platform.

SUMMARY

Hydroponic technology can be used for the sustainable production of green fodder and it will be very useful for small and marginal dairy farmers who are having small land holdings. If hydroponic fodder is cultivated properly under controlled climatic conditions, the dairy farmer can save money spent on feed. This method helps in reducing the use of fertilizers, environmental pollution and soil erosion, and also saves water and other natural resources. Farmers can adopt small- or large-scale hydroponic production units following low-cost devices and sustain green fodder supplements round the year for profitable livestock production. Particularly the dairy farmer who is having a limited area for fodder cultivation can reap the benefits of hydroponic green fodder cultivation.

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