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Hydroponics fodder production for sustainable livestock husbandry in Arunachal Pradesh: A review

Doni Jini[1]* • Joken Bam[1] • Sourabh Deori[2] • Rajesh A Alone[1] • Thejangulie Angami[1]

[1]ICAR Research Complex for NEH Region, Basar- 791101, Arunachal Pradesh
[2]ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya

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ABSTRACT

Arunachal Pradesh being one of the northeast state having different livestock population comprising mithun, yak, cattle sheep and goat but the production and productivity is low with respect to census population. One of the major reasons behind low production and productivity is inadequacy of quality green fodder. Further with rapid non-agricultural development there is shortage of land, manure, labour and further uncertain natural calamities put a constant stress on round the year fodder production especially during lean period. Thus, Hydroponic is the best alternative method as it requires less space, efficient water utilization, short duration for growth and less carbon footprint in terms to labour and energy. The fodder produce under this system is more palatable and harvested at 7-8 days. Many studies have found it enhance the milk production due to its rich nutrient compare to normal production. The finest hydroponic fodder for Indian conditions are maize and barley. Leafy vegetables like spinach and coriander can also be cultivated hydroponically. The different hydroponic production techniques include deep water system, drip, aeroponics, ebb and flow system, nutrient film technique, and wick system. Thus, provide ample scope for round the year quality fodder production for optimum milk production and thereby sustainable livestock production under changing climate change situation.

1. Introduction

Arunachal Pradesh, one of the largest states in the North Eastern Region of the country is with huge floral, faunal, and cultural diversity. It is home to over a hundred ethnically diverse tribes whose main occupation is agriculture and livestock rearing. The 20th Livestock Census (2019) reported 3,39,221 cattle, 3,50,154 mithun, 24,075 yak, 6,379 buffalo, 1,59,740 goat and 7,345 sheep in Arunachal Pradesh. The state has two unique bovine genetic resources *viz*., mithun (90.64% of the total population) and yak (41.74% of the total population). But in spite of population, state has not made much progress in terms of productivity, product diversification, and economic returns from animal husbandry over the years. One of the major causes for the slow progress in livestock sector is attributed to the scarcity of green fodder, especially during winter. Farmers have to depend on collection of tree fodder and grasses from the forest to meet the green fodder requirement of their animals. This practice involves labour and time; and suitable only for few animals. During the lean period i.e. between October to February farmers largely depend on dry fodder like paddy straw. There is huge deficit for both green (35.6%) and dry (26%) fodder in India as per (Rachel Jemimah *et al*., 2015). Accessibility of quality green fodder is vital to maintaining optimum health and production of ruminants. The livestock farmers of Arunachal Pradesh could be broadly categorised into three based on their fodder utilisation practices i) pastoral communities that migrate with their livestock for better pasture, ii) those who let their animals loose to roam and graze freely in the forest or open fields and catching them for marking (tagging or ear notching), treatment for sale/slaughter, and iii) those that practice semi-intensive farming with their animals kept in a farm setting. Dairy farmers concentrated around urban and semi urban areas to supply for the demand of dairy product in urban markets face most difficulties due to limited area, capital, water and

*Corresponding author: donoxini@gmail.com

manpower required for green fodder round the year. Hydroponic fodder production technology presents a promising way for quality green fodder production all-round the year. This unique technology of growing plants without soil using nutrient water under controlled environment require limited space, with right nutrient attaints early maturity and higher yields. Water and fertilizer are conserved, as they can be reused. The fodder is more palatable and relish by the animals enhancement in milk yield by 13.73% (Naik *et al.*, 2013) is reported with feeding hydroponic fodder to lactating cows.

Basic Principle of hydroponic fodder production system

Hydroponics is the growing of plants under controlled environment without soil. In hydroponic functions of soil in plant growth i.e., supply of nutrient and support are provided through other means.

Environmental factors for hydroponics

Environmental factors important for hydroponic fodder production. The suitable temperature is around 19 to 22 ºC, with 60 percent humidity, 2000 lux intensity of light,12 to 16 hours day length and minimum 3 minutes air circulation at span of 2 hours. (Shit et al., 2019).

Fodder crops suitable for hydroponic system under Indian condition

Among various fodder barley followed by maize are preferred due to their faster growth, availability of seed, more biomass production and cheaper than other crops. (Naiket al.,2015). Apart from cereals various vegetables like Spinach, coriander can be successfully grown under this system

Advantages of hydroponic production system.

***Required lesser Space*:**

Hydroponic fodder system needs lesser space in comparison to other system and suitable for urban farmers in cities apart from rural condition.1000kg maize fodder can be produced from an area of 45-50 m^2 whereas in conventional method land area of around 25 acres is needed for optimum production (Naik and Singh 2013, Rachel Jemimah et al. 2015). Under this system one metre square area is sufficient for feeding green fodder for two dairy milking animals. (Yvonne Kamanga, 2016).

***Efficient water utilisation*:**

As the water is supplied directly to the roots there is less wastage of water. For producing one kilogram of hydroponic fodder only 1.5-2.0 litres of water is required whereas under conventional system the water requirement is 73ltrs for barley, 85 litres alfalfa and 160 litres for Rhodes grass which is much higher compared to Hydroponic system (Rachel Jemimah et al., 2015, Yvonne Kamanga, 2016).

***More time efficient*:**

Under hydroponic system it requires time period of 7 to 8 days to grow from seeds to fodder stage whereas in conventional fodder it requires up several weeks to grow. Yield of hydroponics maize fodder is 5-6 times higher than conventional production system on fresh basis (Naik et al., 2014). Hydroponic maize fodder has significantly lower moisture, ether extract (EE) and Total Ash; and higher DM, CF, NFE and TDN compared to traditional maize fodders (Kamat et al., 2020).

***Round the year fodder production*:**

Fodder can be produced irrespective of land availability, natural calamities (irregular monsoon, extreme hot weather), pest infestation, damage by animals, non-availability of manpower, machine etc.

Low carbon footprints:

The hydroponic production system is less harmful to environment, eco-friendlier as it efficiently utilized land or space, water usage, fuel compared to conventional fodder production system were different chemicals are used to enhance the production. Thereby increase reducing the load on land for fodder production.

***More economical*:**

As it requires less space, labour, more efficient water utilization. Feed cost for maize fodder production in hi-tech greenhouse was (Rs 4.0 - 4.50/kg) as reported by (Naik *et al,* 2014), which was due to high initial cost for establishing the greenhouse whereas under low cost system, the feed cost for producing per litre milk production was reduce to around 25 to 20 per cent.((Boue *et al.* 2003, Rachel Jemimah *et al.* 2015).

Effect on animal production

Hydroponics fodder Increased milk yield up to 16.5 % fed on hydroponics maize fodder supplementation was recorded (Kumar et al., 2020). Naik et al., (2014) reported increase in milk yield up to 13.7 %, whereas it was 7.8 % when supplemented with hydroponic barley fodder (Reddy et al.,1988). Improvement in conception rate and overall herd health was also recorded with feeding the cattle with maize fodder grown under hydroponics system (Naik et al.,2015).Maize fodder grown under hydroponic system can substitute upto 30% protein in calf starter .Partial substitution of calf starter with hydroponics maize fodder at 4% protein level was enough to maintain growth performance

of crossbred calves and at 7% level of protein the overall bodyweight gain improved significantly (Rajkumar et al.,2017). When total mixed ration constitutes of hydroponic fodder of either maize or barley the daily milk production increase 8 to 14.0% than conventional fodder (Rachel Jemimah et al.,2015; Yvonne Kamanga 2016).

Different Hydroponics methods

Deepwater culture (DWC): Hydroponic method of production in which plants are completely submerged in nutrient water solution and obtain constant supply of oxygen along with the required levels of nutrition round the clock. Plants grow faster and known to be healthier than the ones grown on regular soil. As the roots are submerged underwater for all day, care should be taken that the air pump works continuously to maintain the oxygen levels in the water. Sometimes the root mass grows so large that it clogs irrigation system and its not suitable for efficient feed production.

Drip system: In drip system separate reservoir is used for keeping the nutrient solution. Pump is used to provide water or nutrient solution for individual plant roots in required proportion. (Raphael and Colla, 2005). The required nutrients are supplied at slow rate using small outlets, the excess solution is either recirculated or drain out.

Aeroponics. In Aeroponics system the growing plants roots are suspended and sprayed with an aerosol of nutrient solution. Plant roots get more quantity of dissolve oxygen and required nutrients. The unused nutrients and water are recirculated again through solution tank for reirrigation (Lakhiar et al., 2018). This system is more efficient than traditional hydroponic system.

Ebb and flow: The system consists of a plant growing tray with a built-in programme timer which can be adjusted to control pump supplying water or nutrient solution to the growing tray till it attains the height of overflow valve. The overflow valve generally is placed 2 cm underneath the root top. Mechanical filter is used to avoid entry of small plant roots. Further this system also reduces the occurrence of various disease in the root of plant in the growing tray.

Nutrient film technique (NFT): Dr. Alen Cooper developed this technique in 1960 to address the drawbacks of ebb and flow system. Under this system plant receives the nutrient solution continuously through various channels via pump (Domingues et al., 2012). The racks are positioned at suitable angle to enable the flow of water up to the lowest point and further the excess water is diverted from shelf into the gutter where it is further collected in solution tank or container for reuse (Guo, 2017). The only shortcoming of this system is that the germinated seed flows downward due to its tilt angle and when rate of flow is less the upper layer does not receive sufficient moisture for germination.

Wick system: This is the simplest hydroponic system were there is no use of any mechanical or electrically operated device like pump, sprinkler etc. The plants receive the enriched nutrient through a wick cord that runs from roots of the plant to the solution based on principle of capillary action. The major disadvantage is clogging due to continuous flow.

Housing system

Hi-tech greenhouse: The Hi-tech greenhouse consist of automatic control unit with regulator for temperature, humidity and ventilation. The water and light from time to time is control through various devices. Different fodder crops can be grown under this system but cost of production for growing of rabi crops in particular barley, wheat etc is high compared to other crops. For establishment of such unit with daily production of 600kg maize fodder was found to be approximately 15 lakhs during 2010-2011 as reported by ICAR Research complex for Goa.

Low-cost greenhouse type hydroponics fodder cultivation unit: This type of unit can be prepared using bamboo, wood structure. The watering is done by using micro sprinkler manually or self-regulating system. For manual system knapsack or backpack sprayer at frequent intervals is used. A report from farmers of Satara district of Maharashtra revealed that for day-to-day production of 30 to 350 kg fresh fodder by using wood structures under shade net the cost per house was ranging from Rs 6,000 to 50,000. (Naik et al, 2014).

2. Conclusion

Good quality green fodder is required for optimum milk and meat production. Growing human population, rapid urbanization, low availability of forage land and unpredictable climatic condition poses a great challenge for round the year green fodder supply around the world. Arunachal Pradesh, with majority of its livestock farmers concentrated in peri-urban areas to cater to the demand for dairy and meat products from urban consumers, may encounter difficulties ensuring a steady supply of high-quality green fodder to meet production needs in the future. Hydroponic fodder production system could be a great alternative solution to the currently practiced foraging or conventional fodder production. The system is easily adaptable with the limited land holding by small cattle farmers as it requires lesser space, efficient water usage, shorter germination time, independent of weather or season and gives low carbon foot print. Also, feeding cattle with

hydroponics fodder have been proven to increase the digestibility and enhance the milk production. Hence, adoption of hydroponic fodder production system may be instrumental in increasing the livestock productivity of Arunachal Pradesh through round the year quality green fodder production for sustainable livestock husbandry under climate change scenario.

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