

Development of Small Scale Indoor Hydroponic Fodder Production System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Field experiment was conducted to develop a small scale indoor hydroponic fodder production system (May- June 2021). Green fodder supply to the domestic animals is most important factor to improve their health, body weight, milk yield and thus obtaining maximum economic return. Land degradation and urbanisation reduced the area available for the green fodder production. India has 10.7% of world livestock population but only having 2.29% of its land mass and this is putting a huge pressure on land and water resource. Vertical growing of crop and minimising the usage of water is the best solution to solve this problem. Hydroponic technology helps to achieve very high yield and also provides better control over the crop production. Indoor cultivation eliminates the problem of weeds and pests and the use of pesticides and herbicides. Artificial lighting overcomes the disadvantage of seasonal variation of solar radiation and provides continuous source of energy supply. The study shows that green fodder can be efficiently grown at indoor condition. Hydroponic technique helped to achieve yield of 7.535 kg per day with a water requirement of only 4.78 litres per kg. The combination of red and blue LED lights supplied continuous energy for 12 hours a day for the better growth of crop. Results clearly show that the indoor hydroponic fodder production system with artificial supply of light can be recommended for the farmers to meet their fodder requirement.

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1. INTRODUCTION

Hydroponics technology is a science of growing plants in nutrients rich solutions instead of soil. Technology advancement has introduced hydroponic technology for green fodder production. The hydroponics green fodder could be a novel way of feeding dairy animals to improve productivity [1]. Different types of fodder crops like barley, oats, wheat, sorghum, alfalfa, cowpea and maize can be produced by hydroponics technology. Sprouting results in enzymatic activities which leads to hydrolysis of proteins, carbohydrates and lipids into their simpler components, thus increases the digestibility in animals [2]. Seed is the major input for hydroponic fodder cultivation which contributes about 90% of the total cost of production. 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. Temperature of about 22 to 32°C and relative humidity of 40 to 80% is the optimum growth condition for fodder maize [3]. Light emitting diodes provide solution for this problem as they consume less energy and very compatible in use. Blue and red colours have been found to be the best blend for plants and vegetables which promotes good plant growth. Combination of 23% blue and 77% red give good results with good plant growth [4]. Hydroponic fodder is very nutritious. It is rich in proteins, fibres, vitamins and minerals. It has rich metabolizable energy, crude protein and digestibility [5]. Hydroponic green fodder enhances lactation in cows and improves body weight of calves. Thus, the study aims to develop a small scale indoor hydroponic fodder production system.

2. MATERIALS AND METHODS

The experiment was conducted at KCAET Tavanur, Kerala Agricultural University.

2.1 Raw Material

Locally available maize seed was selected for green fodder production. Seed was cleaned and damaged were separated before soaking. Seed was kept for soaking for 20 hours followed by germination in gunny bags for 24 hours. Germinated seeds were then transferred to trays of dimension 58.5 cm x 23.5 cm x 2.5 cm (Fig. 1). Tray was having one drainage hole per square centimetre area to keep the root mat safe from standing water. Tray should have drainage holes, else water gets accumulated in the root mat and leads to mould growth [6].

2.2 Design of Fodder Production Unit

Frame work for the unit was done using angle iron (Leg: 4 cm x 4 cm, tray holder: 2.7 cm x 2.7 cm) because of its durability and strength (Fig. 2). Total height of the unit was 1.95m, width 0.6m and length 2.4m. Four tier structures having two compartments in each with 0.45m distance between the tiers was built. According to Islam et al. [7] greater chemical composition was observed on 9th day of growth so it is recommended to harvest on that growth stage. Four trays were introduced in the unit daily. On the 9th day four trays of fodder was harvested (which was introduced in the system on the first so had 8 days of growth). This cycle was continued for 10 more days and daily harvest was weighed and noted.

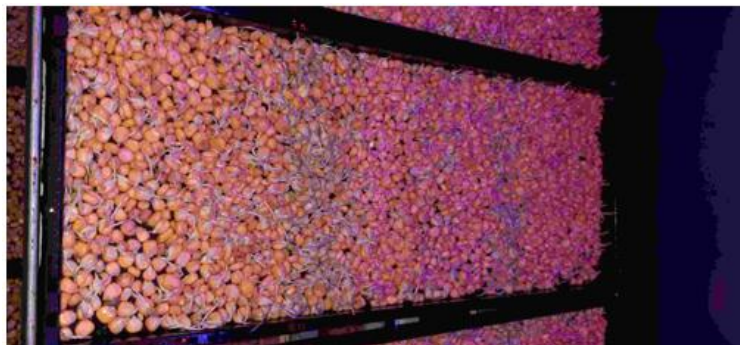


Fig. 1. Germinated seeds in tray

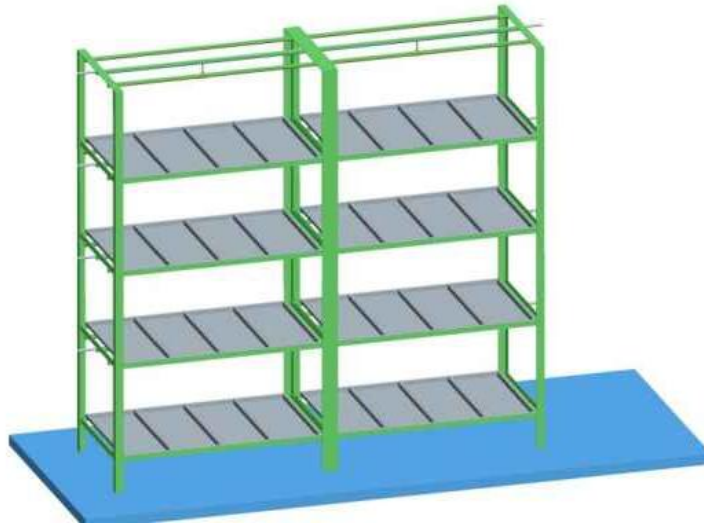


Fig. 2. Designed model of fodder production unit

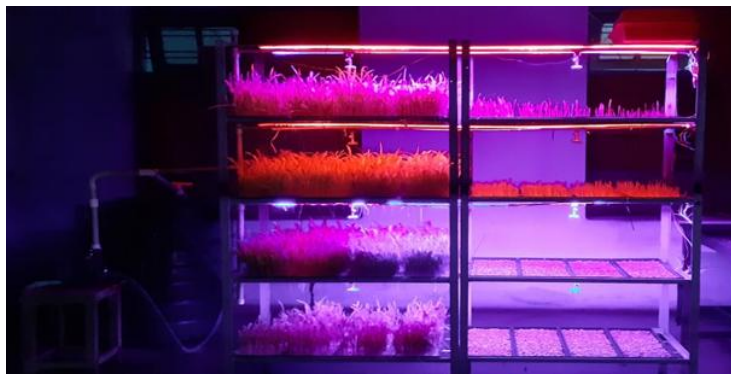


Fig. 3. Developed green fodder production unit

2.3 Irrigation

Islam et al., [7] studied the effect of seed rate and water level on yield of fodder by laying out in a factorial design with 3 replications for each fodder in 27 trays and the result showed that 0.6 kg of seed rate per tray, 2.5 l water level per tray works best. Accordingly, 350 gm seed rate per tray and 1 litre water level was used for this experiment. Irrigation was done using foggers of 16 lph capacity. Automation of irrigation was achieved using a timer (Multispin UTR 1044, 12V DC digital timer). Fogger was operated for 35 seconds after every 20 minutes for 12 hours a day so that each tray gets 1 litre of water every day.

2.4 Source of Light

Bian et al., [8] studied the effect of light supplementation on energy-use efficiency,

vegetable nutrition and photosynthesis improvement in a protected horticulture system. Results showed that the light-use efficiency increased by 55, 114 and 115% for mixed red and blue LEDs with Photosynthetic Photon Flux Density (PPFD) at 100, 150 and 220 $\mu\text{mol m}^{-2} \text{s}^{-1}$, respectively. Luechai et al., [9] investigated the effect of using LED lighting in the growth of hydroponic crops. The experiment was conducted in a dark enclosure. Super bright LEDs of different types, fluorescent red to blue with a ratio of 3:1 was used. Results showed that the use of artificial light (LEDs) the light intensity is lower than natural light. Accordingly medium density (60 LED per meter) LED red (66.66%) and LED blue (33.33%) was used in this study for 12 hours a day to provide continuous supply of light energy to the growing fodder.

2.5 Chemical Analysis

The various methods used for the chemical analysis of the fodder includes determination of moisture content, crude protein and crude fiber by hot air oven method [10], Kjeldahl's method [10] and AOAC 978.10 respectively.

3. RESULTS AND DISCUSSION

Green fodder was harvested on the 9th day. After 8 days of growth green fodder was harvested for 10 days continuously. Average yield of 8.5 kg and water requirement of 4.23 litre per kg was observed in the unit. Maximum yield and minimum yield per tray from the production unit (Fig. 3) was observed to be 2.4 kg and 1.5 kg respectively. Constant energy supply by LED grow lights, uniform water application by fogger and humidity maintained in the system credits to the higher growth rate. On an average one kg of input (seed) gave 5.38kg output (fresh green

fodder – Fig. 4) (Table 1). Conventional methods to grow fodder takes 83 m³ of water to produce 1 ton of fodder and one hectare land is utilised to produce 50 tons of fodder [11]. Hydroponic model took only 4.23 m³ of water to produce 1 ton of fodder and thus saving 95% of water. Within 10 m² area it is possible to produce 30 kilograms of fodder daily. This system eliminates the dependency on seasonally varying solar energy, usage of pesticides, problem of weeds, labours and optimizes the fodder growth. Average shoot length and average root length of green fodder was observed to be 32.3cm and of 15.6cm respectively. From the chemical analysis, it was revealed that 76.63% of moisture content, 13.42% of crude protein and 12.6% of crude fibre was there in the fodder.

Total cost of the fabrication was Rs.17030. Total cost of production was Rs. 69 per day. Benefit cost ratio of the equipment was 1.60.

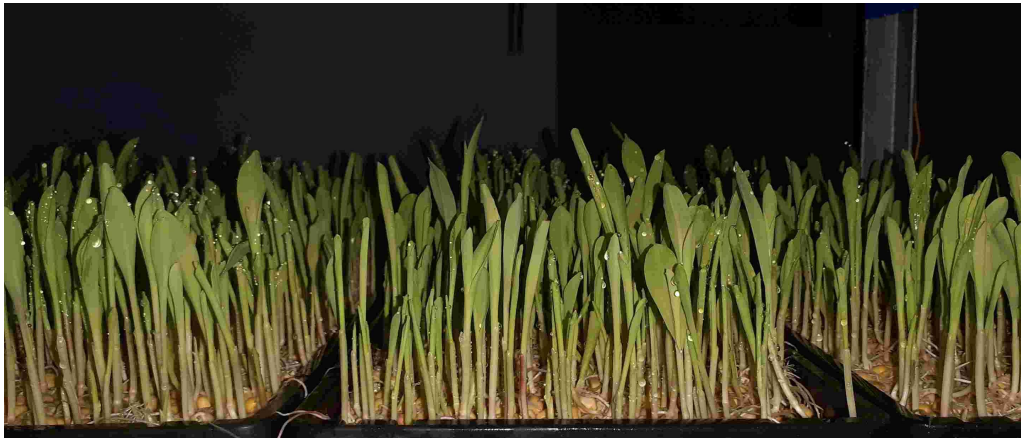


Fig. 4. Green fodder

Table 1. Yield and water requirement of fodder

Harvest	Yield (kg) at each harvest (9 th day)	Water requirement (litre/kg)
01	8.417	4.28
02	8.663	4.16
03	8.785	4.10
04	8.659	4.16
05	7.832	4.60
06	8.793	4.09
07	7.769	4.63
08	8.889	4.05
09	8.792	4.09
10	8.456	4.26
Average	8.5055	4.23

4. CONCLUSION

Results of this experiment clearly show that hydroponics is one of the best and advanced method for the utilization of water and land efficiently. The proposed design produces 8.5 kg of fodder per day. Based on the daily fodder requirement of farmers, it is easy to modify the design. Developed indoor hydroponic fodder production system is superior to conventional method and can be adopted by farmers. This study mainly concentrated on the development of a fodder production system. Statistical analysis is required for the optimisation of developed design by growing the fodder in different treatments. The model can be further modified as solar (renewable) assisted system for its energy consumption. Study must be conducted to know effect of different light intensities to optimise the growth of fodder.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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