The Pharma Innovation Journal 2023; 12(5): 2677-2679

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 2677-2679

www.thepharmajournal.com
Received: 26-03-2023
Accepted: 30-04-2023

V Sankar
Assistant Professor, Mecheri Sheep Research Station, Pottaneri, Tamil Nadu, India

P Senthilkumar
Assistant Professor, Mecheri Sheep Research Station, Pottaneri, Tamil Nadu, India

N Sribalaji
Assistant Professor, Department of Livestock Production Management, Veterinary, College and Research Institute, Namakkal, Tamil Nadu, India.

P Nalini
Assistant Professor, Mecheri Sheep Research Station, Pottaneri, Tamil Nadu, India

J Muralidharan
Professor and Head, Mecheri Sheep Research Station, Pottaneri, Tamil Nadu, India

Corresponding Author:
V Sankar
Assistant Professor, Mecheri Sheep Research Station, Pottaneri, Tamil Nadu, India

Economics of production of shade-dried Azolla (*Azolla pinnata*) meal insemi-arid region

V Sankar, P Senthilkumar, N Sribalaji, P Nalini and J Muralidharan

Abstract
The present study was conducted to evaluate the production cost of fresh azolla and shade-dried azolla. Azolla pit of 5 m X 5 m with 0.3 m depth was made and 24 ft X18 ft, 160 GSM tarpaulin was spread over the pit thensoft soil to a height of 20 cmwas spread over the sheet. Then the pit was filled with three-fourth levels of water, 20 kg of cow dung dissolved in 30 litres of water was added to the pit and the fresh azolla culture 6 kg was added to the pit. Azolla was multiplied rapidly and it was ready for harvest in 7-8 days. Azollaharvested and dried under the shade for 48 hours. The shade-dried azolla was ground to reduce the particle size (3 mm) and used for experimental feeding. The average production of fresh and dried azolla was 1350 kg and 137.7 kg respectively from the pit of 25 m^2. The ratio of shade-dried azolla produced from fresh azolla was 1:10. The shade-dried azolla can be stored for a long time and can be used as a replacement for protein in the conventional concentrate mixture. Based on the recurring expenses the unit cost production of one kg fresh and shade-dried azolla was Rs 1.26 and Rs 14.52 respectively. This shade-dried azolla cost about half of the cost of the concentrate mixture.

Keywords: Azolla, production, production cost

Introduction
Fodder scarcity and high cost of concentrate feed is the main problem in the livestock industry. Due to the increase in the conventional feed cost, researchers are more focused on alternative feed sources to reduce the feed cost and cost of production of animals. Among unconventional feed, azolla plays the main role in reducing feed cost as well as providing good quality protein. Azolla is easy to cultivate, harvest, store, has high nutritive value and multiplies in a short time (Prabina and Kumar, 2010) [6]. In addition to the protein, azolla is a good source of minerals and biopolymers and is low in lignin content compared to other unconventional feeds (Upendra Kumar *et al.,* 2020) [12]. Azolla has a symbiotic relationship with *Anabaena azollae,* blue-green algae which is responsible for the fixation of atmospheric nitrogen. The carbon particle provided by the azolla to the algae help for the growth and survival of the algae. The azolla growth and biomass yield are completely controlled by the environmental temperature, relative humidity, light intensity, azolla species and shade level provided by the shade net (Rex Immanuel, 2019) [7]. Under partial shade growth of azolla was higher than in complete shade environmental conditions (Sadeghi *et al.,* 2013) [8]. Azolla is an economic substitute for the protein and fiber content of feed for livestock. Many workers reported that the conventional protein supplement can be replaced with azolla up to 15 percent. Feeding the azolla as fresh is very difficult because the daily requirements of ruminants cannot be cultivated as fresh on a daily basis; At the same time fresh azolla in bulk quantity could not be consumed by the ruminants completely. So as an alternative to fresh azolla, partial shade-dried azolla which is less in volume, high in nutritive value and having long self-storage time can be used. Anitha *et al.,* (2016) [1] reported that sun-dried azolla can be used as alternative feed in livestock. The present study was carried out to calculate the economics of the production of sun-dried azolla.

Materials and Methods
The experiment was conducted at Mecheri Sheep Research Station, Tamil Nadu Veterinary and Animal Sciences University (TANUVAS). Geographically this station is located at a longitude of 77º 56'E, latitude of 11º45'N and altitude of about 650 feet above MSL. Theclimate of the area is generally hot, semi-arid and tropical with an average rainfall of 831.4 mm. The damaged pit having the dimensions of 5 m X 5 m with 0.3 m depth already made was used for this experiment. This pit was spreaded with 24 ft length X 18 ft breath, 160 GSM

tarpaulin and soft soil to a height of 20 cm were spread over the sheet. The azolla pit was fully covered by a 60: 40 green shade net, which allows 40 percent sunlight into the pit. The pit was filled with three fourth levels of water and the level was maintained throughout the experiment period. Cattle dung of 20 kg dissolved in 30 litres of water was added to the pit and mixed uniformly. Superphosphate of 30 grams dissolved in 10 litres of water was added to the pit in a zigzag manner. Once the pit was ready the fresh azolla culture of 6 kg was added to the pit. Azolla multiplied rapidly and was ready for harvest collection in 7-8 days. Cultivated azolla was harvested and dried under the shade for 48 hours. The shade-dried azolla was ground to reduce the particle size by 3mm which can be used for animal feeding.

Results and Discussion

Azolla was harvested on alternative days and allowed for shade drying because direct sunlight affects the colour and nutritive value of azolla. After shade drying the dried azolla was stored for feeding. The shade-dried azolla can be stored for a long time due to a reduction in moisture level and bulk density. The azolla production varied from season to season. In the summer season, production was less compared to other parts of the year. Fernández-Zamudio *et al.*, (2010) [4] reported that species of azolla will survive in high temperatures (above 30 °C) and also in low temperatures (below -4 °C). In the summer season, increase in the environmental temperature leads to evaporation of water. Azolla is sensitive to dryness, and the level of water in the azolla bed is important for better production of azolla. Azolla growth is highly sensitive to the depth of water level. Low water level promotes the growth of other algae which leads to a decrease in growth and production of azolla (Biswas *et al.*, 2005) [2]. The average production of fresh and shade-dried azolla was 1350kg and 137.7 kg from the pit of 25m^2, respectively in 6 months. Thus the average yield of fresh azolla per day was 300 g per m^2 of the pit. These azolla productions was higher compared to previous workers Anitha *et al.*, (2016) [1] reported that the yield of Azolla was reported around 120 g/m^2/day fresh weight per water trough. These difference may be due to nutritional density and the higher water levelin the azolla pit as compared to the water trough. Table 1 shows the total expenditure required for azolla production. In azolla production, the recurring cost which includes dung, superphosphate and labour cost for bed preparation, harvesting of azolla was Rs 1044.4 for six months. The total azolla and shade-dried azolla produced were 1350 kg and 137.7 kg respectively. The shade-dried azolla produced from fresh azolla ratio was 1:9-10. It clearly indicated the dry matter content of azolla was about ten percent. By the reduction of moisture, azolla can be stored for a long time. Based on the recurring expenses the unit cost of production of one kg fresh and sundried azolla was Rs 1.26 and Rs 14.52. The azolla production cost was lower compared to previous work reported Rs.5.65 by Cherryl *et al.* (2013) [3] and Rs 6.65 by Sireesha *et al.* (2017) [11] per kg shade-dried azolla, this may be due toincreased labour cost and other recurring cost of azolla production. Similar result was reported by Saini *et al.* (2020) [10] that the cost per kg fresh Azolla was Rs 1.36 and shade-dried Azolla was Rs 13.61. These increases in the cost of production compared to previous result might be due to variability in labour cost. The labour cost increased the production cost of azolla, ifthe farmers themselves are involved in azolla cultivation it will reduce the production cost of shade-dried azolla. Ghodake *et al.*, (2012) [5] reported that shade-dried azolla meal can replace 15 percent of the concentrate mixture in Osmanabadi kids and Sankar *et al.*, (2020) [9] reported that shade-dried azolla meal can replace 10 percent of concentrate feed in Mecheri lambs. So result of the study revealed that azolla could effectively reduce the cost incurred for concentrate mixture purchase.

Table1: Economics of Azolla production in a pit (5 m x 5m)

Particulars	Cost of particulars	Quantity	Amount (Rs)
Total Production period: 6 months			
Capital Expenditure			
Labour charge for bed preparation	1 m^2 = 40	5 m x 5 m	1000.00
Cost of silpauline sheet	1 m^2 = 15	7.6 x 7 m=53.2	798.00
Cost of shadow sheet	1 m^2 = 55	6 mx 6 m=36	1980.00
Total			3778.00
Recurring Expenditure			
Cattle dung@20kg per month	1.0 per kg	120 kg	120.00
Super phosphate@30g per month	8 per kg	180 g	1.64
Labour charges one hour per week	Rs 50 per hour	24 man hours	1200.00
10% depreciation of the capital expenditure for 6 months			377.80
Total			1699.44
Yield of fresh azolla	-	1350 kg	
Unit cost of fresh azolla per kg	-		1.26
Labour cost for drying and storage for 6 months	Rs 50 per hour	6 man hours	300.00
Total production cost for shade-dried azolla			1999.44
Yield of shade-dried azolla	-	137.7	
Unit cost of s shade-dried azolla per kg	-		14.52

Fig 1: Azolla pit 2. Collection of azolla 3. Weighing of azolla 4. Drying of azolla under shade 5.shade-dried azolla

Conclusion

The production rate of azolla depends on surrounding environmental conditions like water temperature, humidity, shade and water level. Under optimum nutrition, azolla multiply rapidly within 7- 8 days. The cost of production of shade-dried azolla was Rs 14.52 per kg. It is three times less than the cost of the concentrate mixture. Shade-dried azolla has long storage life and can replace the concentrate feed mixture to reduce the feeding cost of animals.

Acknowledgement

The authors want to show gratitude to the Tamil Nadu Veterinary and Animal Sciences University, Chennai for providing all kind of facilities required to carry out the current investigation.

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