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Study on hydroponic maize fodder effect on milk production

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Abstract
Green fodder is the natural diet for livestock for a sustainable dairy farming and dairy cattle requires green fodder for high milk yield. However, it cannot available throughout the year especially in dry land situation, it is difficult to have access for green fodder due to many reasons; non-availability of irrigated lands for fodder production, higher labour cost and small land holdings. Thus, hydroponic maize fodder (HMF) is an effective solution for fodder scarcity and is very promising for sustainable livestock production in different regions of the world and nowadays it plays significant role in augmenting fodder shortage of small holding dairy farmers in scarce rainfall areas. Hydroponics fodder production involves growing of plants without soil for a short duration (7 day). In hydroponic fodder production system, it can be possible to grow 13-14 kg of green fodder from one kg of maize seeds. In this study results revealed that feeding of HMF to lactating cows with partially reduced concentrate mixture increased the digestibility of nutrients of crude protein (13.62 vs 10.24 %), ether extract (3.24 VS 2.13 %), nitrogen free extract (64.23 vs 50.23 %) and lower crude fiber (13.86 vs 23.25 %), total ash (3.12 vs 9.02 %) and acid insoluble ash (0.23 vs 1.12 %) and significantly higher mean body weight (431.77), before test milk yield (11.76 kg/day), during test milk yield (14.56 kg/day), 0 % Fat corrected milk (9.16 kg/day), fat (4.46 %) solids not fat (9.11 %) was recorded with cows fed with HMF 14 kg/day + 10 kg dry sorghum straw /groundnut haulm + concentrate feed (4.0 kg) as compared to conventional green fodder (CGF) respectively and further, there was increase in milk yield per day to the tune of 16.5 % more in fed with HMF (Rs. 435) than CGF (Rs. 363) leading to increase in net profit (Rs. 241/day/animal).

Keywords: Hydroponic fodder, maize, dairy cow, milk yield

Introduction
It is a well-accepted fact that feeding dairy animals are incomplete without including green fodder in their diet. Green fodders are staple feed for dairy animals. However, due to many reasons, green fodder production has been facing a serious crisis. The major constraints in production of green fodder by dairy farmers are the reaching record high price of hay and grain, unavailability of land for fodder cultivation due to small land holding size of small and marginal farmers, more growth time and natural calamities (Sefa Salo, 2019) [18]. Further, milk producers are forced to utilise extra concentrates for optimum milk production. On account of this cost of milk production is higher. Farmers and ranchers across the country are in need of a dependable and affordable feed for their livestock due to the non-availability of quality fodders round the year aggravates the constraints of the sustainable dairy farming (Naik *et al*., 2013) [9]. Due to these constraints, hydroponics technology becomes as an alternative way for growing fodder for farm animals (Sneath and Mclntosh, 2003 and Naik, 2014) [10, 20]. Green fodders produced by growing seeds without soil but in water or nutrients rich solutions are known as hydroponics green fodder. The green fodder is produced from grains, having a high germination rate and grown for a short period of time in a special climate controlled chamber that provides the appropriate growing conditions (Sneath and Mcintosh, 2003, 20) and it consists of grass with grains, roots, stem and leaves as compared to the only stem and leaves part in the conventional grown fodder. Dairy animals producing up to 12-15 litres milk per day can be maintained by feeding green fodders. Hydroponic fodder is much more easily digestible, full of nutrients and enzymes that the energy spent on this digestion process would be far less with the resultant extra energy being diverted to milk production and growth and compared to conventional methods of growing fodder, hydroponic fodder requires lesser space and produces highly nutritious fodder than soil farming. Inclusion of green fodders in ration of dairy animals decreases amount of concentrate feeding and thus increases profit. Of course hydroponic fodder cannot substitute green fodder and hay completely, as it lacks in fibre content. But it is definitely a better substitute for packaged feeds.

The adoption of this technique has enabled the production of fresh forage from corn, oats, barley, wheat, horse gram and other grains (Rodriguez-Muela *et al*., 2004) [16]. The technology of green fodder production is especially important in the regions where forage production is limited (Abu Omar *et al*., 2012) [3] due to natural calamities.

The dairy farmers in central dry zone of Karnataka worried about the ever increasing price of cattle feed, scanty rainfall and shrinking land size in the state ensures lack of availability of green fodder and hay in sufficient quantities. The spiralling cost of packaged cattle feed adds to the cost of dairy farming has left the dairy farmer with many challenges for milk production. Therefore, for economical and sustainable dairy farming, fodder production round the year is highly essential and hydroponic fodder provides an effective solution for above problems. In view of this, the present experiment was conducted with the following objectives.

1. To establish demonstration units on rapid production of nutritionally rich green fodder through hydroponic technology to meet the nutritional requirements of dairy animals throughout the year.
2. To study the effect of hydroponic green fodder on quality and quantity of milk production and also the economic viability of hydroponic technology as compare to traditional feeds.
3. To empower and popularize the dairy farmers on sustainability of dairy units by hydroponic technology.

Materials and methods

Hydroponic device: Fully automated –weather neutral hydroponic fodder machine are controlled by software equipped with automatic water spray. Machine dimension about 33 ft length X 12 ft width X 8ft height. It has pre - selected program for various seeds, machine can grow up to 10-15 types of seeds irrespective of outside weather. Fully automated all weather hydroponic fodder machine has special arrangement to provide aluminium water channel very stable and long lasting for rust free operations unit allows setting for repeated on-off water setting, which runs throughout the day, for each row irrigation facility was provided with one mister connected to 0.5 hp motor controlled by a cyclic timer and consumes minimum labour, minimum power (4.5 KW, Single phase 24-32 units/day), minimum water (1-2 litres/day/kg) and it has water recycling and water treatment for best result, refrigeration design for uniform cooling and better growth of fodder and resistance to fungus and bacterial infection compared to only water 8 days cycle. Trays are made from unbreakable, food grade big (205 ft X 1.5 ft) hydroponic trays and have protrudes in the bottom for easy drain for excess water, the size of tray was 2.5 feet×1.5 feet the system has water filter and pump; this has shelf life even beyond 10 years. Water-soaked seeds are kept on trays and allowed to germinate (sprout) inside controlled environment for a short duration and the average output/day was 500 kg of HMF (seeds input 36 tray/ day)

Growing of hydroponic maize fodder: Seeds were washed with normal tap water before seeds ready to be placed in machine, one per cent Sodium Hypo-Chloride solution prepared in tub and seeds were soaked in solution for 15 minutes to provide good immunity against fungus. Weak seeds that comes up in the water are not good seeds and should be removed out and rinsed the seeds in the clean water, seeds are soaked in 400 -500 ppm KH_2PO_4 solution for 3 hours, drained out all the water and transferred the seeds in gunny bag for germination for next 16-18 hours, ensure the gunny bag is kept wet by sprinkling water on timely manner (every 1-1.5 hours) and keep the gunny bag in airy and dark place for best germination than evenly spread the germinated seeds in the trays with approximately 2.0 kg/ 3.75 sft of seeds in each tray, then place the tray in the bottom section (sprouting section – bottom section where the gap between two rows is small- approx. 4 inches) for 4 days. After 96 hours, all trays need to be shifted to the upper section of machine (upper section – where the gap between 2 rows is approx. 10 inches). The first batch of lush green feed trays is ready for harvest, the fresh yield of the HMF from one kg maize seed obtained 7 kg of fodder can be fed to the animals on 8th day with a DM content of 11.42 %. The HMF looked like a mat of 20–30 cm height consisting of germinated seeds with roots and leaves. Take the fodder mat from the trays and trays can be reused for next cycle, repeat the steps from day 1-7 every day with fresh trays. This way, after the 7th day, every day, it will be able to harvest green fodder and continue with daily feed to the cattle.

Hygiene: Seeds must be stored in clean and dry place**,** wash your hand well before and after handling the seeds at all stages, wearing gloves is essential while soaking / adding nutrients and keep a separate pair of footwear (or Gum boots) for entering the system in order to keep the system environment, bacteria free and any other contamination, cleaning of the water tanks and trays should be done as per requirement based on observation, ensure that the bucket used for the soaking must cleaned regularly to prevent any kind of infestation and clean the tray every time after the fodder mat is removed and tray is reused for the next cycle, for the better fodder yield, seeds should have 95 % or higher germination percentage.

Fig 1: Hydroponic Green Fodder Production Unit

Fig 2: Even spread of germinated maize seeds

Fig 3: Lush green sprouted hydroponic fodder

Fig 4: University Key official visit to unit

Fig 5: Feeding Hydroponic fodder to lactating cows

Experimental details: An experiment was carried out under Rashtriya Krishi Vikas Yojana (RKVY) project at Zonal Agricultural and Horticultural Research Station, Babbur farm, Hiriyur, Chitradurga district Karnataka to find out the effect of feeding hydroponics maize fodder on milk production in lactating cows by reducing the concentrate mixture. The study was conducted based on average body weight and milk yield of twenty lactating cows (avg. BW 408 kg, avg. milk yield 11.10 kg) were divided into two equal groups i.e. first group offered with (T_1):CGF 14kg/day + 10 kg dry sorghum straw /groundnut haulm + concentrate feed (6.0 kg), the second group (T_2) fed with: HMF 14 kg/day + 10 kg dry sorghum straw /groundnut haulm + concentrate feed (4.0 kg) were prepared and fed to the animals. The HMF fed animals offered partial withdrawn of two kg of concentrate mixture (T_2) as compared to (T_1). The experiment was conducted for a period of 90 days and all the animals were kept in well ventilated, clean cement floored shed and ration was offered twice daily in equal divided doses, which was offered once in the morning and evening with clean drinking water was made available *ad lib* throughout the experiment period. Milking of the cows was performed twice daily at 6.0 AM and 4.0 PM by machine milking. Data on milk yield, Fat and SNF in the milk, income and expenditure on feeding was recorded. The feed offered, residues left and milk yield were recorded by a digital weighing balance. The body weights of the animals were recorded as per the Shaeffer's formula (1998) [19]. The milk samples were analysed for fat and solid not fat (SNF) by milk analyser. The 4 % fat corrected milk yield (FCMY) was calculated (NRC, 1989) [11] using the formula: FCMY (kg) = (0.4 x kg of milk) + (15 x kg of fat). The feed conversion ratio (FCR) was calculated as 'kg feed intake per 4% FCM kg milk yield/ day. The data was subjected to t test for analysis at 5 per cent significance level.

Table 1: Effect of hydroponic maize fodder (HMF) on production performance over conventional green fodder in the milch animals

S. No.	Attributes	Conventional green fodder	Hydrophonic green fodder	Savings on
1.	Area	1000 sq mt	500 sq. mt.	Land
2.	Land fertility	Essential	Not essential	Soil conditioning
3.	Fertilisers	Required	Not required	Savings on fertilisers
4.	Water and electricity requirement	Very high	Very low	Water and power saving
5.	Labour requirement	More	Less	Savings labour
6.	Fodder production in days	60 to 70 days	7 days	Time saved on the growth period
7.	Fencing and protection	Required	Not required	Savings on fencing cost
8.	Fodder yield dependency	On climate, rain, water	In a controlled environment	No dependency
9.	Fodder utilisation by animals	Partial	Complete	Reduction in fodder waste
10.	Fodder feeding practices	By chopping	Not required	Savings chopping time and labour
11.	Fodder availability	Seasonal	Year-round	Consistent fodder availability
12.	Weed	Weedy	Weed free	free of chemicals
13.	Disease	Disease contamination	Disease free	free of chemicals

Results and discussion

The biomass yield of HMF was recorded as 7.0 kg per kg seed. Similarly 6.2 kg per kg seed obtained by Atturi krishna murthy *et al.* (2018) [4] and Naik *et al.* (2014) [10] reported as 5.5 kg and Krishna Murthy *et al.* (2017) [7] reported as 4.82 kg fresh biomass yield per kg seed.

The nutrient content (13.62 % CP, 3.24 % EE and nitrogen free extracts 64.23 %) in HMF (T_2) were higher unlike crude fibre, total ash and acid insoluble ash contents were no gain as compared to the conventional green fodder used (23.25, 9.02 and 1.12, respectively) (Fig:1). The nutrient content of the

HMF observed in this experiment was parallel to the reports of Atturi krishna murthy *et al*., 2018 [4] noticed higher CP, EE and total ash contents in HMF as 15.8, 3.74 and 64.57, respectively compared to maize grains. This increase in protein was due to a decrease in dry weight through respiration during germination (Sale, 2015) [17]. Similarly, Sneath and Mclntosh, (2003) [20], have reported in their studies as the sprouted grain are rich source of anti-oxidants and related trace minerals such as selenium and Zn and feeding of the sprouted grains improve the animals productivity. In Dung *et al*. (2005) [5] study, there were an increase in crude protein and some mineral concentrations (except B, Mn and K) in sprouts in comparison to the grain. According to Resh (2001) [15], sprouting of grains affected the enzyme activity, increased total protein and changes in amino acid profile, increased sugars, crude fibre, certain vitamins and minerals, but decreased starch and loss of total dry matter. The enzymes also cause the inter-conversions of these simple components leading to an increase in quality of amino acids as well as the increase in concentrations of vitamins (Plaza *et al*., 2003) [13].

Hydroponic fodder can help to improve the quality and quantity of milk production. Research results indicated that milk yield was improved. The data on daily milk yield, milk composition and 4 % FCM yield were given in table 1. The data revealed that 16.5 % increased milk yield was observed in T_2 over T_1 in this study which was similar to the observations of Naik *et al*. (2014) [10] reported as 13.7 per cent increased milk yield (4.64 vs 4.08 kg/day) on feeding of HMF to cows because it is palatable and the germinated seeds embedded in the roots are also consumed along with the leaves of the fodder plants without any wastage and Reddy *et al*., 1988 [14] reported as 7.8 per cent milk yield improvement on supplementation of ration containing hydroponic barley fodder to cows. The higher milk yield was due to high protein content in the ration containing HMF which may be due to the higher DCP and TDN content of the ration had been reported by the earlier workers (Moghaddam *et al*., 2009; Naik *et al*., 2014 and Helal, 2015) [8, 9, 6]. Likewise, in another study from Canadian, there was an increase in 3.6 kg per day milk production per cow over the lactation period. These improvements might be due to a stimulated appetite of the cow as a result of the daily feeding of fresh green fodder. The data revealed that significantly higher mean body weight (431.77), before test milk yield (11.76 kg/day), during test milk yield (14.56 kg /day), 4 % Fat corrected milk (9.16 kg/day), fat (4.46 %) solids not fat (9.11 %) and lower values of days in milk (1.41), crude protein (0.20) and dietary crude protein (0.14) was observed in treatment receiving with cows fed with HMF 14 kg/day + 10 kg dry sorghum straw /groundnut haulm + concentrate feed (4.0 kg) as compared to conventional green fodder (CGF). Similar kind of observation recorded with reduction in the requirement of concentrate mixture along with increase in the milk production in cows had been observed in field condition by the farmers due to feeding of hydrophonic fodder (Anonymous 2012, 2013; Naik *et al*. 2013) [1, 9]

The gross income cost of feeding and benefit cost ratio were presented in table 3. The average daily gross income was 16.5 % more in animal fed with T_2 HMF (Rs. 435) as compared to T_1 (Rs. 363). The feed cost /litre milk in T_2 and T_1 were Rs. 13.29 and Rs. 21.49 respectively, *i.e.* saving of 34 % of feed cost on per litre of milk (Rs. 8.2) this might be due to the less feed cost of HMF and partially withdrawing of concentrate mixture fed to the lactating cows improved in the performance of the animals (Naik *et al*, 2017) [12] and it was reflected in net profit animal/day and also benefit cost ratio. Increased net profit of Rs. 117/cow/day was recorded in animals fed HMF (T_2) (Rs. 241) as compared to T_1 (Rs. 124). Higher B:C ratio was observed in T_2 (2.2) than the T_1(1.5). Naik *et al*. (2014) [10] reported in their studies as higher net profit of Rs. 12.67/cow per day due to feeding of hydroponic maize fodder.

Table 3: Mean body weight and milk composition of experimental Animals

Source of Variation	Mean body weight (MBW)		Before test Milk yield (kg/day)		During test Milk yield (kg/day)		0% Fat corrected milk (kg/day)		Fat (%)	
	Control group	**Experimental group (HMF)**	**Control group**	**Experimental group (HMF)**	**Control group**	**Experimental group (HMF)**	**Control group**	**Experimental group (HMF)**	**Control group**	**Experimenta l group (HMF)**
Mean	415.13	431.77	11.05	11.76	12.13	14.56	8.13	9.16	4.06	4.46
Standard Deviation	7.62	13.14	0.61	0.58	0.62	0.75	0.60	0.62	0.31	0.33
T Critical (P=0.05)	1.99		1.99		1.99		1.99		1.99	
T Calculated (P=0.05)	6.89		5.30		15.76		7.60		5.60	

Table 4: SNF, DM, CP and DCP of milk composition of experimental Animals

Source of Variation	Solids Not Fat (SNF) (%)		Days in Milk (DM)		Crude Protein (CP)		Dietary Crude Protein (DCP)	
	Control group	**Experimental group (HMF)**	**Contro l group**	**Experimental group (HMF)**	**Contro l group**	**Experimental group (HMF)**	**Control group**	**Experimental group (HMF)**
Mean	8.69	9.11	1.63	1.41	0.29	0.20	0.16	0.14
SD	0.64	0.67	0.12	0.10	0.02	0.02	0.02	0.02
T Critical (P=0.05)	1.99		1.99		1.99		1.99	
T Calculated (P=0.05)	2.90		8.5		23.54		6.81	

Table 5: Economics of milk production/ANIMAL/day (average of 90 days)

Particular	T-1: Control group Unit cost (Rs.)			T-2: Experimental group (HMF) Unit cost (Rs.)		
Green fodder	14	3	42	14	4	56
Dry sorghum straw /Groundnut Haulm (Rs. 3/kg)	10	3	30	10	3	30
Concentrate feed (Rs.1100/50kg)	6	22	132	4	22	88
Other costs (labour, land power, machine etc.)			35			20
Total Expenditure on feeding			239			194
Feed cost /litre milk (Rs.)			21.49			13.29
Gross income (Milk yield)			363			435
Net profit animal/day			124			241
B:C Ratio			1.5			2.2

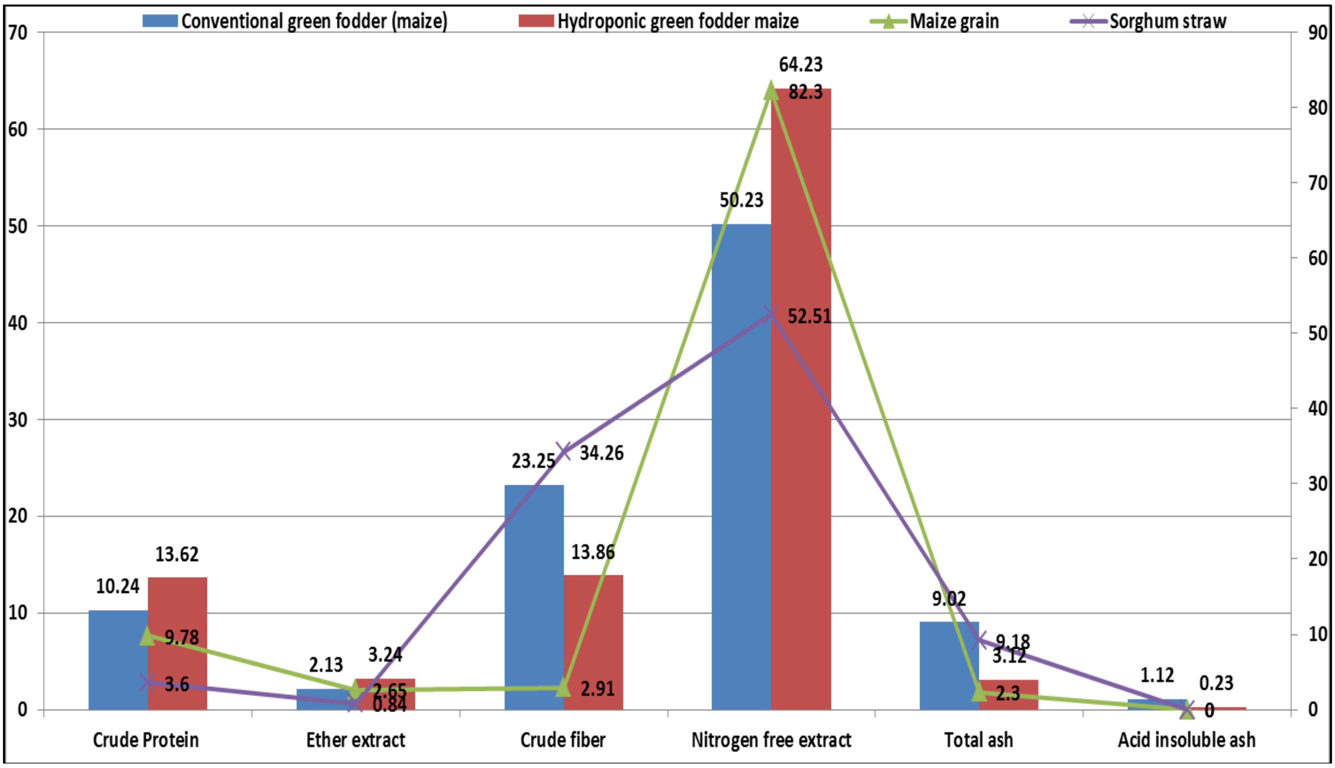

Fig 6: Nutrients comparison chemical composition (on % dry matter basis) of maize green fodder

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